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Biographical Sketch of Maynard M. Boring

President of ASEE

The dean of the nation's industrial talent scouts, the new president of ASEE, is well known on the campuses of this country's colleges, particularly those with engineering students.

In more than 30 years of recruiting for the General Electric Company, he has interviewed more than 100,000 prospective candidates for the company's technical training programs.

He is also recognized as one of the nation's leading authorities on manpower and spends considerable time serving on various councils, boards and committees dealing with the problem.

He was born January 26, 1893 in Denver, Colo., eighth in a family of nine children, four of whom were boys and five girls.

His early education was obtained in the public schools of Denver after which he worked his way through the University of Colorado, from which he was graduated in 1916 with a bachelor of science degree in electrical engineering.

On September 1 of that year he was recruited for the General Electric Company's test program at Schenectady, N. Y., the same program to which he later recruited thousands. Two years after joining G.E., in 1918, he was appointed head of motor test. Another year saw him as assistant general foreman of the testing department.

From the factory he was transferred to recruiting and from 1922 to 1940 was in charge of recruiting engineering graduates. In his search for top talent for his company, he has traveled the length and breadth of the land, visiting engineering college campuses for prospective G–E employees.

In 1940, the company increased his responsibilities and made him assistant to the vice president of engineering and put him in charge of not only the recruiting but also the training and education of the technical graduates taken into the company's technical programs.

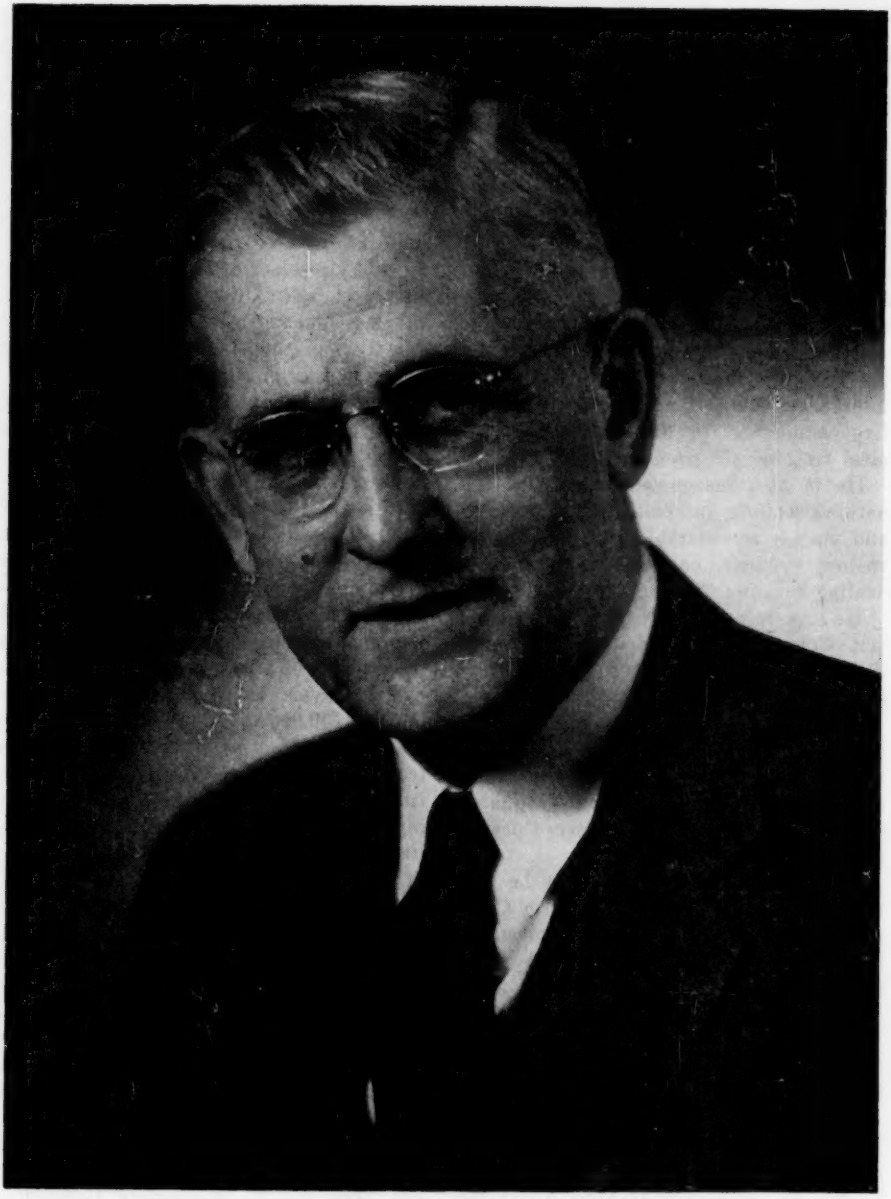
In 1946, he was appointed manager of engineering personnel, and, in 1954, was named consultant on engineering manpower.

It is interesting to note that many of the graduates whom he has recruited have progressed to positions of importance in his company. One of them is vice president of manufacturing and another, the vice president of engineering, now heads the division of which Boring is a member.

His travels have taken him approximately 750,000 miles in search of college seniors qualified to enter his company's technical programs. In addition, he has traveled almost countless miles in serving as an advisor on manpower problems, particularly those relating to the shortage of technically trained manpower.

He has estimated that he has spent as much as half of the normal working time in serving on manpower and other bodies. His interest in education makes it only natural that his home community should recognize his talents, and, in 1937, he was elected a member of the Scotia, N. Y., Board of Education. From 1939 to 1949 he was president of the board.

Joining ASEE in 1922, he served as a member of its council from 1935 to 1938, has been on its Manpower Committee since 1940 and was chairman from 1940 to 1943. He has served on the committee on financial policy, on the committee on Humanistic-Social Project; and the com-



M. M. BORING

General Electric Company

mittee on Evaluation of Engineering Education.

He represented ASEE on the Engineers Joint Council as chairman of the special survey committee and on the Engineering Manpower Committee of the Engineers Joint Council as chairman in 1955. He served as vice president of ASEE from 1951 to 1953 and recently was elected president for 1955–1956.

He was consultant to the War Production Board on Selective Service from 1942 to 1946; is a member of the New York State Appeal Board of Selective Service; member of the Committee on Specialized Personnel, Office of Defense Mobilization; and was a member of the United States Team in 1954 to the European-United States Education Conference, Zurich, Switzerland.

He studied European education and industrial utilization of engineers by traveling throughout western Europe in the fall of 1954.

The new president is a member of the National Society of Professional Engineers, the National Conference Board for Industry of the National Society of Professional Engineers and served as vice chairman of that board in 1955.

He was initiated Eta Kappa Nu in 1937, and elected an honorary Tau Beta Pi in 1941. He received an honorary degree of doctor of engineering from the South Dakota School of Mines in 1952.

His keen insight into the manpower situation is exemplified by the following excerpts from a speech which he made to college students in April of 1942, only five months after Pearl Harbor:

"The trend in college education indicates that a large percentage of those young people who would normally come into industry in the next few years will be diverted into military channels, and a decreasing number will be available to industry.

"We are going to leave you a world torn by war in which we will expect you to correct the social structure and the economic structure, as well as to rebuild the physical things. All of Europe must be rebuilt, and in your thinking you shall have to come to the realization that you must in some way create the same standard of living in European countries that we ourselves enjoy, so that those jealousies that eventually break out into actual wars will be eliminated. You must take a larger part in the economical and social phases of our civilization than ever before.

"I have found from my experiences in contacting young men that most of them seem to feel that their entry into industry will be a very temporary thing, that there is going to be a complete collapse in the industrial world following the war effort; and yet, history shows that even though there may be a short, deep depression immediately following the war, caused by the readjustment necessary in changing over from the building of war material to peace material, this must be followed by a long period of high productivity.

"The fact that there has been practically no building of homes, of heavy transportation facilities, and of power generating equipment for nearly ten years, indicates that there will be a great shortage of such materials facing us immediately after the war is over.

"I feel that we can assure you that the period of rebuilding following the war effort will be one that will be extremely interesting, that you will have a job to do, and that you will have plenty of responsibility, and that you will have grand fun doing this job."

Gardening has been among his hobbies and the irises which he raises are considered the best in the area. Roses are another of his favorities. Fishing—he has a camp at Schroon Lake—is another hobby which he enjoys when he can find the time.

He has been married 33 years. In addition to his wife, he has a daughter, Mrs. W. Curtis Gray of Scotia, and a granddaughter, who, needless to say, is his pride and joy.

A Year of Decision

Editorial by M. M. BORING, *President of ASEE*

The coming year poses a period of real decision. Finalizing the work of the Committee on Evaluation of Engineering Education, new and far-reaching military legislation, President Eisenhower's committee meetings on the public schools this fall, all indicate a good start on a new outlook in our methodology and our goals.

Many, if not all, of our educational institutions will start a revamping of all engineering curriculums according to the recommendations of the Committee on Evaluation, and difficulties and apprehensions will be encountered. We must ask ourselves several vital questions, such as, Can our average freshmen adjust themselves to the new proposals? Can our present faculties adjust themselves to the proposed changes? What will this do to our laboratories? etc.

There are still some questions concerning the Reserve Bill and the Engineering Manpower Commission has tried to keep close to the legislation. This group has testified before both the House of Representatives and the Senate. Both bodies have passed a bill containing a clause permitting 18½ to 20 year old volunteers and men declared "in short supply" by the Government to complete their active service in six months plus a period in a reserve unit and includes a method of screening out reservists from a ready to a stand-by reserve.

Assuming final passage of this proposal, our student population should be able to make better plans for their future and much of the uncertainty encountered since Korea should disappear. We should have a greatly stabilized student body with a better understanding of the necessity of getting to work.

Probably our greatest problem lies in the area of secondary school preparation. The ASEE must work hard to assist the public schools in revamping their programs. This is primarily a local program so that each engineering college must participate.

There is much evidence that the public and our public school people feel the need for changes. Most states have established citizens committees for the public schools. These committees are hard at work studying the problems of our educational system. The influx of students has already started. The shortage of adequate teachers is being felt now. Each of our colleges should undertake a program of cooperative effort with at least the principal schools that supply engineering freshmen in order to develop further interest in those subjects that are vital for entrance into an engineering or scientific field.

Material published by the American Physics Society last April indicates that the percentage of students studying mathematics and science in the secondary schools has dropped from approximately 25 per cent in 1900 to under 4 per cent in 1954. Surveys made throughout the engineering colleges indicate that the average length of time in an undergraduate curriculum is not four years but four and seven-tenths years—the seven-tenths of a year being necessary to overcome secondary school deficiencies.

Is it not possible for us to work with the various state committees for the public schools to rectify this situation? As an experiment, I have brought these problems to the attention of the New York State Committee of which I am one of the directors. These problems have not

been sufficiently recognized in this state, and the members, who have contact with all of the boards of education and administration of the public schools of the state, are very much stimulated to take constructive action.

Considerable concern has been expressed about this problem by members of Congress, by the Department of Defense, by the colleges and others. It appears that the time is ripe for the ASEE to band together for constructive action. It is hoped that President Eisenhower's committee will consider the curriculum as one of the most vital parts of the study for assistance that must be given to our educational system.

It might be well for the ASEE to consider some changes in organization as we are growing larger yet are operating under pretty much the same umbrella as we did when we were just a small group. Our problems are multiplying daily. We might well consider changes in the structure of both the Council and of the administrative committee.

Many of our Sections have become very large and travel distances, at least in some cases, seem to keep down attendance and participation in sectional meetings. If we recognize that our annual meeting should be a period of reporting and of consolidation of activities carried on during the year, it is clear that active participation in section meetings is paramount.

The problem of adequate supply of teachers has become critical. Ways and means must be found immediately to alleviate the teacher shortage. The ASEE must give close attention to this matter during the year ahead.

Industry is finally beginning to recognize its responsibility for financial support to the schools. Many organizations are anxious but do not know how. It is imperative that the ASEE develop realistic, constructive plans to assist industry in making decisions on how financial aid should be handled. It should be of paramount importance at all of our section meetings this year to bring to the attention of industry proper programs for adequate financial support. We all recognize that many times scholarships and fellowships really just add another burden on our colleges and are not very useful in assisting the basic problems.

Your council, your administrative committee and your president will spend much time and effort on these and the many other problems that are before us. We will need help from the membership and hope to develop plans so that we will have as near to 100 per cent participation as possible. Suggestions from individuals and from groups will be most welcome at any time.

Meeting Notices

ECPD 23rd Annual Meeting—Toronto, Canada, October 13–14, 1955, King Edward Hotel.

ASEE General Council—During meeting of Association of Land Grant Colleges, Michigan State College, November 15–17, 1955.

ASEE Annual Meeting, Iowa State College, Ames, Iowa, June 25–29, 1956.

Nuclear Engineering and Science Congress, Cleveland, Ohio, December 12–16, 1955.

College-Industry Conference, Marquette University, tentatively set for February 1 and 2, 1956.

Do You Know—

► The attendance at the Annual Meeting at Penn State was the largest ever. This was the second meeting held at Penn State and each time they set a record. Particularly noticeable was the increased number of women and children. Each member of the Society owes Ken Holderman, General Chairman of the Local Committee, and all members of his Committee a vote of appreciation. Dean E. A. Walker can be proud of his staff and their wives—they did a wonderful job of planning, and the plans were effective. For more detailed information, see John Mattill's article on *Highlights of the Annual Meeting.*

► All of us also owe appreciation to the many committee, division, and program chairmen who planned the programs and conducted the meetings. To those who appeared on the programs as speakers, panel members, or discussers, we also sincerely say, "*Thank you* for a job well done."

► A successful Annual Meeting involves great effort on the part of a great many people; it is doubtful if anyone knows how many. Only through such cooperative efforts can an Annual Meeting be successful. As a Secretary who came into office in the middle of all the planning, I deeply appreciate the effectiveness of the preliminary work of my predecessor, A. B. Bronwell, and his staff. All of you who were involved with the Annual Meeting in one way or another lived up to the confidence placed in you and when you knew you could not get much guidance from the Secretary's office, you continued with your assignments. For that I am indeed grateful.

► Students refer to some of their class experiences as "rat races," "put through the wringer," etc. After having lived through my first Annual Meeting as Secretary of the Society, I now know what they mean! I found out the Secretary's day begins at six A.M. and ends only in the wee hours of the morning when the inevitable discussions and conversations which follow meetings and conferences can be terminated. I missed conferring with many, and to them I apologize and say, "I hope we can get together next year." Mrs. Collins and myself enjoyed the opportunity to meet so many of you at the reception; we hope to meet you again next year at Iowa State. And if the reactions of my children are typical, you made a mistake by not having brought yours to Penn State.

► In electing Maynard M. Boring of the General Electric Company as President, the Society has gone outside the area of university personnel for the second time in its history. The previous president not associated with a university was R. I. Rees, of the American Telephone and Telegraph Company, in 1929–30. In a year when industry as well as each college of engineering is being asked to "evaluate the Evaluation," President Boring should be a great asset to the Society. The new vice president responsible for General and Regional Activities is Frederick C. Lindvall, Chairman, Division of Engineering, California Institute of Technology. The new vice-president by virtue of being Chairman of the Engineering College Administrative Council is William T. Alexander, Dean of Engineering, Northeastern University. George Farnham, Vice-President, Engineering Books,

The Ronald Press Company, was re-elected Treasurer.

► Dean B. R. Teare, Jr. of the Carnegie Institute of Technology and Dean W. L. Everitt of the University of Illinois are the retiring vice presidents. To them and to Dean N. W. Dougherty of the University of Tennessee, retiring president, the Society expresses its thanks for the years of service unselfishly given to ASEE.

► The new Editor of the JOURNAL OF ENGINEERING EDUCATION is Edwin C. McClintock, Jr., formerly of the University of Virginia. Professor McClintock's background is in literature and speech, but he knows engineers and engineering by virtue of being in the College of Engineering at the University of Virginia, teaching courses in their rather unique program of Engineering English, editing their technical publications, directing their engineering library, and performing a multitude of other duties. At the present time he is a member of our Engineering School Libraries committee.

► Copies of the Final Report on Evaluation of Engineering Education were distributed at the Annual Meeting. Copies can now be purchased from the Secretary's Office, University of Illinois, Urbana, Illinois, at the following rates:

1 to 50 copies	25¢ each
50 to 100 copies	20¢ each
100 or more copies	12¢ each

It is preferred that payment accompany each order.

► The *1955 ECRC Directory and Review of Current Research* unfortunately was not available in time to be sold at the Annual Meeting. This book is published every two years and it can be purchased for $2.00 per copy from:

Engineering College Research Council
Renato Contini, Secretary
New York University
University Heights
New York 53, New York

Checks should be made payable to Engineering College Research Council.

► The 1956 Annual Meeting will be held at Iowa State College, Ames, Iowa, June 25–29. Professor Lowell O. Stewart, Head, Department of Civil Engineering, is the General Chairman. He and many of his committee chairmen were at Penn State, carefully studying procedures and making notes regarding improvements which would make their meeting even better. Those of you at the Annual Meeting saw the "*Aim for Ames in '56*" sign above their literature. We should all adopt that as our slogan and use it to give the Annual Meeting a little publicity, particularly at Section Meetings.

► Plans for the Open and Closed Conferences on *Theoretical Engineering* are progressing. This is another project jointly sponsored by The National Science Foundation and ASEE. The Closed Conference will be held at the California Institute of Technology and the Open Conference at the University of Michigan. Dates will be announced later.

► The Fourth Summer School for Chemical Engineering Teachers at Penn State was attended by 150 out-of-town people. The papers presented were stimulating and will be published by the Chemical Engineering Division; the Editor of this Division is A. H. Cooper, Professor of Chemical Engineering, University of Maryland.

► The Open Conference on Thermodynamics, jointly sponsored by the National Science Foundation and ASEE, also was well attended. A brief report of the conference appears elsewhere in this issue.

W. LEIGHTON COLLINS, *Secretary*

The Elements Glow as They Complete the Whole

By N. W. DOUGHERTY

President ASEE, 1954–55

(*Presidential Address, Annual ASEE Meeting, University Park, Pa., June, 1955*)

A mosaic is more than a combination of the elements; it is an arrangement in selected proportion showing forth the genius of the artist. If he has poorly selected materials, the wrong combination of colors or disproportionate sizes of the materials, he will be handicapped in his creation. However, a good artist will make a reasonable production out of good, but disproportionate, materials. Arrangement and proportion have more to do with the final result than the color and shape of the elements; motif and workmanship determine the excellence of the mosaic.

Education is the composite of many experiences; it is the integration of learning, emotions, judgment, integrity and a motivation for service. Many elements are essential for its greatest fruition. Learning from books is a part of it; living from childhood to manhood is a part of it; experiences of pleasure and pain are a part of it; hope, aspirations and longing are a part of it; motivation, a will to do and a drive for excellence are major parts of it. If the student has not confidence, self-reliance and a willingness to stand alone he will never be educated.

In our discussions we are apt to emphasize the elements rather than the whole. For example, this morning we will hear reports on two activities, the one an evaluation of engineering education and the other a study of a major segment of education. Yesterday we heard about graduate work and its evaluation. The overall objective is the production of an engineer; the details of the production have to do with the elements, their shaping, their individual contribution and their blending as a composite of all the elements.

Proportioning the Elements

We often ask the question: "May the methods of analysis and design be applied to the engineer himself?" Certainly not as an automatic mechanism, but possibly as a self-motivating organism. Distinguishing characteristics of an engineer are that he exercises discretion and judgment. Here is one definition of his work: [1]

> The practice of professional engineering within the meaning and intent of this act includes any professional service, such as consultation, investigation, evaluation, planning, design, or responsible supervision of construction or operation, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, work or projects, wherein the public welfare, or the safeguarding of life, health, or property is concerned or involved, when such professional services require the application of engineering principles and data.

This you may say is a staid, pedestrian, prosaic description of the work of an engineer. It lacks the fire and spark of many of his activities and the vision of his greater works. These depend upon the individual and are not necessarily required of all practitioners. As teachers we are concerned with the regimen for

[1] *Model Law*—Joint Committee.

the best, though too often we have set our pace for the pedestrian.

The biographer of Hermann Schneider, by quoting an ancient Indian poem, undertakes to describe the man and the engineer.[2]

> Fearless, singleness of soul, the will always to strive for wisdom; open hand and governed appetites; and piety, and love of study, humbleness, uprightness, heed to injure nought which lives, truthfulness, slowness to wrath, a mind that lightly letteth go what others prize; and equinimity, and charity which spieth no man's faults; and tenderness toward all that suffer; a contented heart, fluttered by no desires; a bearing mild, modest, and grave, with manhood nobly mixed with patience, fortitude and purity; an unrevengeful spirit, never given to rate itself too high;—such be the signs, O Indian Prince! Of him whose feet are set on that fair path which leads to heavenly birth!

Schneider would probably be the first to say that this picture is optimistically drawn, yet if we combined it with the prosaic legal definition we begin to get a description of what we, as educators, are trying to produce.

Academic Elements

The Committee on Evaluation has said some of the elements are mathematics, science, engineering science, technology, the humanities, social science and professional practice. Some of these are so interesting and intriguing in themselves that we are apt to think that our objective is to learn science, engineering science or the humanities rather than to become an engineer whose knowledge and skill is measured by his balance and integration of these separate subjects and skills. Dr. Pollard, in a paper delivered to the Southeastern Section, called it initiation into a community of likeminded practitioners. To be a member of the community of engineering, the person must have a certain kind of knowledge and experience, he must be sympathetic with the group and he must have a peculiar approach to problems and their solution. He is not a scientist, he is not a mathematician, he is not a sociologist or a writer, but he may use the knowledge and techniques of any or all of these in solving engineering problems.

The elements may be combined into a whole by using a formula developed from previous experience. The mixing and the weighting will depend upon good teaching, and more importantly on real assimilation by the student himself. Normally we do not suggest there be a separate program for each individual, but that is what actually happens. I may emphasize one element and my neighbor another, but *the learning is by the student* and his sorting and digesting mechanism determines what he learns and assimilates. Fortunately, education is not like a factory where the superintendent pours in the raw material and a uniform product comes from the line; it is a process where the raw materials are very individual and the final product, if there has been any education, is more individual. Each student does his own blending, coloring and shading of the subject matter he learns.

A few years ago I suggested that educational maturity is the goal. More than ever I am convinced that this is the major objective. We admit youngsters from high school and we graduate young beginning engineers. They must grow from a fledgling to a young eagle; they must put away childish things and take their place among the men. The football coach arranges a hard scrimmage to "separate the men from the boys." It may be a sort of ordeal for some, but it is a separation which must come either in school or in later life. The teacher's job is to help them develop intellectually as rapidly as they can mature. We must arrange our instruction in desirable subject matter areas in such a way that the growing student may consume and digest large quantities. We must remember that an overdose may be as harmful as hunger and scarcity; digestion is the objective and

[2] *Ambassador to Industry*—Clyde W. Park.

not forced feeding or forced dieting because of the leanness of the diet. Rapid and healthy growth is essential, not hothouse plants of figures and facts or encyclopedias or prodigies of rote learning, but oaks of the forest of understanding, originality, self-confidence and intellectual maturity. Students should feel about education, as did Mrs. Miniver about the new hat: "It does something to me."

In a Westinghouse leaflet are these two short paragraphs: [3]

> Something special happens when a new turbine-generator goes on the line. It is not quite like anything you have experienced . . . a combination of quiet rejoicing, assurance that more customers can be served better.
>
> It seems to us that the answer is . . . well, it's *A Way of Life.* Life given to metal and machinery by the brains and brawn of many men, dollars converted into new productive energy, electricity with a magic and miracles at its finger tips.

If we may think and write of a turbine in such terms, how much more may educators think of a way of living for a student who has grown to manhood in an atmosphere of science and engineering and in the association of good teachers.

The objective of the good teacher is to teach himself rather than teach subject matter. His knowledge has become a part of his thought process, and as he labors with his students he reveals his aspirations, his hopes and his desire for knowledge; the subject matter becomes the vehicle by which he makes the revelation.

Since we measure railroads, automobiles, materials, stocks and bonds in money we are tempted to try to measure education in the same coin. Many of us have heard speakers quote figures on compensations for the uneducated, high school graduates and college graduates and convince themselves and their audience that education pays. Surely education is more than dollars and cents. It pays in the coin of the land, but it pays in more than money: "Life consists not in getting and holding, but in being and becoming." Education is more than money and goods; it is living and thinking and understanding and being what you dreamed that you could be.

Education must bend its efforts to get excellence. The average is too low; it must be elevated, and excellence must not be allowed to drift toward good enough.

Formal education, even through advanced degrees, may not be enough. We probably know some Ph.D.'s who have never been outstanding successes as teachers or practitioners, and we know others who have never been to college and who have made names for themselves in engineering. I will make my point by naming a few: Edison, Eads, Westinghouse, Dillworth, and you may add to the list, or I could with equal truth name successes who have had formal college training, as Steinmetz, Roebling, Kettering, Schneider, and again you may name others. These lists probably prove nothing unless we try to identify the common characteristics which led all of them to success. Let me quote from Grantland Rice who may have captured the attitude and the motivation for success: [4]

> To reach the top in any sport—or in life—you need confidence and belief in yourself. Can you imagine Babe Ruth ever considering the possibility of failure? Many years ago, Babe told me, "Once my swing starts, I cannot change it or pull up. It's all or nothing at all."
>
> The qualities of self-confidence and belief in oneself seem to be relatively rare today. They are sometimes even openly ridiculed as naive or worse.

I have spent many years observing athletes and their performance as I have in learning about engineers. They have much more in common than we ordinarily suspect. The same qualities make a champion in athletics as make an engineer.

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[3] *Partners in a Way of Life.*

[4] *The Tumult and the Shouting*—Grantland Rice.

There is a spirit in sports which we should try to capture in all walks of life. Listen to the Psalmist: ". . . and rejoiceth as a strong man to run a race," who hints at the great pleasure in running a race, in meeting equal competition, yes, "for the give and take of competition—not for the puny bauble that goes to the victor, but for the thrill of the actual game."

Personal Characteristics

Success is due to a combination of many qualities, of which technical education is one. Benjamin Lamme hung this legend in his office in order that all who entered might read: "Promotion stops due to personal qualities long before it stops due to technical ability." When we come to teaching personal qualities we are not nearly so sure of ourselves as when we are teaching information, laws, methods and techniques. We drift into thinking that teaching is covering subject matter rather than developing an attitude, a method and an approach. Success in subject matter is easy to measure, but success in acquiring attitude, engineering approach or engineering method is more elusive and more difficult to measure. Determination, motivation will-to-do set the stage for all degrees of success.

You remember the Mann Report.[5] Some of you will remember the questionnaire to engineers which said: "Please prefix numbers to the groups of qualities listed below to show the order in importance that you give them in judging the reasons for engineering success or in sizing up a young man for employment or promotion:

——Character, integrity, responsibility, resourcefulness, initiative.
——Judgment, common sense, scientific attitude, perspective.
——Efficiency, thoroughness, accuracy, industry.
——Understanding of men, executive ability.
——Knowledge of the fundamentals of engineering science.
——Technique of practice and of business."

These were rated in the above order and when given statistical preference the first four had a weight of seventy-five to twenty-five for knowledge and technique. Personal qualities outweighed the technical ability. No doubt this is true in many other activities of life, such as law, medicine, the ministry and all the professions.

We like to believe that the college instruction determines the field of success, and most of the time it does, but there are times when the success is only remotely related to the college courses. We are all familiar with the transfer of our graduates from one branch of engineering to another, as for example, civil to electrical, mechanical to chemical, and all kinds of engineers to air-conditoning. This is not what I mean; this is to be expected since all engineers have much the same general training. Here and there we have an engineering graduate ending up in the ministry, the law and particularly in business. Again, we believe that the engineering education is, at least partially, contributory to success.

Our surprise comes when we view the works of those who have had no formal schooling and their success equals, if it does not exceed, the hundreds of contemporary college graduates. I am thinking of Dillworth and the diesel locomotive, the Wright brothers and the airplane, Edison and his hundreds of inventions, Eads and the Mississippi River Bridge, Westinghouse and the airbrake, and a long catalogue of others who justly deserve fame and fortune. These were able to achieve eminent success along-side others who had far better formal training. The answer, we say, was in the man; he had native genius which was sufficient without the help or hindrance of a teacher. What he needed to know he learned; when such knowledge was not available he developed it.

[5] Carnegie Foundation Bulletin No. 11.

Herbert Spencer sensed the answer about one hundred years ago when he wrote: [6] "Only when genius is married to science can the highest results be produced." He also said that the greatest intellectual deficiency was that of judgment.

How may we as teachers aid our students in developing their genius for engineering works? Emerson has given us a formula: [7]

> Colleges . . . have their indispensable office —to teach the elements. But they can only serve us when they aim not to drill, but to create; when they gather from afar every ray of various genius to their hospitable walls, and by concentrated fires set the hearts of their youth on flame.

The Dillworth biographer may also give us a hint: [8]

> He learned something from books but even more from the demands of the job and from his associates. . . .
>
> He'd recognize a basic idea wherever he saw it, and he'd remember what happened to it the first time. Whenever he was confronted by involved ideas, his first attack was to reduce them to simple terms. He believed in higher mathematics, but only as a tool to prove or disprove ideas that are basically simple.

This latter statement reminds us of Dr. Doherty's description [9] of the mental workings of Steinmetz. He would reduce a problem to basic elements which could be handled by the use of previous knowledge or experience. Often this approach is the key to great success, and it may be followed by a worker of understanding whether he be a Ph.D. or a boy who went to school one day in his life.

Much of the discussion regarding four, five and six year programs, is born of the idea that engineers must learn in college what they need to know in practice. Patently this is impossible, but the discussion goes on apace under many guises. The study and development must continue through a professional career. It is important that the student get, in one or six years of college, an ability to read and understand, to search and to find and, above all, to get a love of learning. Intellectual dolts do not go far in any field, intellectual sluggards may make some progress, but the lover of learning will learn what he needs to know whenever he needs it. In college the student gets a vocabulary, and some introduction to many fields; he, under good teaching, gets the spirit, the attitude and the approach to scholarship in these fields, and if he works at it for many years he may become educated. As engineering teachers we must see to it that all our students get the professional concept whether they stay in school a year or a decade.

A Further Look at the Whole

The engineer is more than a technician; he exercises discretion and judgment. To do engineering practice he must choose between alternatives; he must follow a service motive, and work in a relation of confidence. These responsibilities are superior to technical knowledge or great mechanical skill; they are the heart of professional practice. In addition the engineer must be a citizen in his community, state and nation; he is an ingenious man which determines one of his major contributions to industry, and coequal, but often neglected, he must assume his place as a statesman in an industrial civilization.

Other elements must leaven the whole mass. He is an individualist which means that he must love and promote liberty. Individuals cannot thrive in an atmosphere of collectivism and herd activities. Bulwer Lytton has written: "Personal liberty is the paramount essential to human dignity and human happiness." This I believe.

Somehow the education of the engineer

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[6] *Education*—Herbert Spencer.

[7] *The American Scholar*—Ralph W. Emerson.

[8] *The Dillworth Story*—Franklin Reck.

[9] *The Development of Professional Education*—Dr. Robert Doherty.

must introduce him to the art of living along with his ability to make a living.

The average American is a shrewd judge of quality in mechanical products, from motor cars to radios, but his ability to evaluate quality in men and ideas is not equally developed. He is satisfied with no less than the best in airplanes and plumbing but accepts the second-rate in politics and culture. This discrepancy is often excused by the assumption that rising material standards will inevitably raise intellectual and spiritual ones. . . .

Spiritual force and imaginative drive are the only forms of energy that our engineers cannot harness or measure; it is not surprising that they look at them askance.[10]

This suggests that American lack of interest in art allows the modern artist to be hodge-podge in his work. Dashes of color may represent the fuzzy thinking of our day, but they do not represent the needed productions in art. We may write a symphony which will simulate the sounds in a factory, but this will not necessarily be a production of art.

Machines and processes are to make goods. They must not be allowed to use up all the phases of American living. Ideals, emotions, and the spirit must be developed in our youth. That a machine works should suggest that time is available for thinking and dreaming, rather than to grovel and take pride in our possessions.

Have I painted the lily to be seen and admired rather than the engine which works under the hood? The engineer must partake of the virtues of both, and in such proportion as he has skill, efficiency and power he must do the work of his calling, and as he has vision, philosophy of living and dreams for the future he must contribute to making people happy as well as comfortable.

[10] *The Age of Conformity*—Alan Valentine.

The Whole is Greater Than the Sum of the Parts

Kipling's description of the woman as a rag, a bone and a hank of hair falls far short of man's knowledge of the female of the species. The materials are far short of the mosaic. An airplane is a system beautiful, graceful, efficient; it is a monument to its many designers. No one would describe an airplane by naming its parts.

Engineering education is more than the assembly of many courses, lectures and laboratory exercises; it is a preparation for practicing engineering as a profession. Each and every course should be taught with this as its objective. Mathematics, science, engineering science, technology, and the humanities are the pieces and as they are digested, assimilated and become a part of the student they make the mosaic of engineering. Singly they are but subject matter; when assembled into a whole and activated by a professional attitude they become the distinguishing equipment of the engineer. In applying engineering principles and data to design, consultation, investigation, evaluation, planning and responsible supervision, he will partake of the characteristics of Schneider by being fearless, wise, humble, modest and contented of heart that his work may show forth the excellence of his calling.

Special Notice

Members, please return change of address cards immediately to the American Society for Engineering Education. The deadline for the change of address cards is October 1.

Highlights of the 63rd Annual Meeting of ASEE

By JOHN I. MATTILL [1]

Director of Publications and Assistant Director of News Service, Massachusetts Institute of Technology

The yearly stocktaking of engineering education which constitutes the Society's annual convention was accomplished last summer in the peaceful setting of the Pennsylvania hills. But national and international affairs penetrated even these rural surroundings to cast a note of urgency over the entire proceedings.

Comparing Russian scientific progress with ours, Dr. M. H. Trytten, director of the Office of Scientific Personnel in the National Research Council, declared that while "we have not yet come alive to the problem of developing and properly utilizing technically trained manpower, our greatest competitor has.

"We must look promptly to the soundness and well-being of our entire educational system; our concern must be for the millions who will lose their lives or their freedom if we, who should know better, allow our technological superiority to be frittered away."

In the same tone, Dr. Vannevar Bush, receiving the 1955 Lamme Medal at the annual banquet, called engineering education an endeavor "exceedingly important to the strength and welfare of our country."

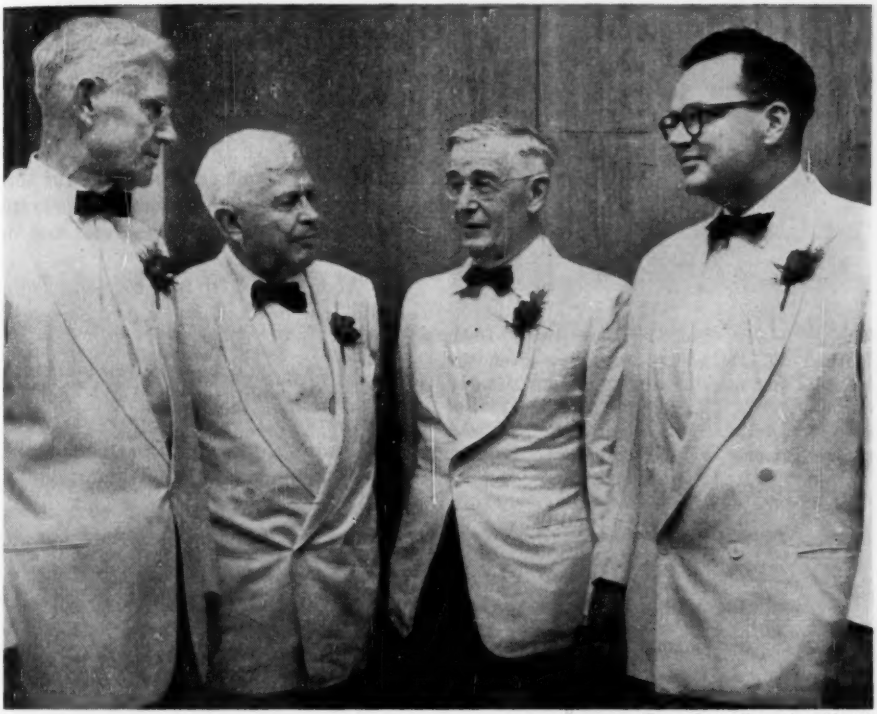
[1] Much of this report is drawn from information prepared for the press during the 1955 Annual Meeting. The author acknowledges the important contributions of Mr. John Whelden, director of public relations at Rensselaer Polytechnic Institute, and of Professor Christian K. Arnold of the Ordnance Research Laboratory at the Pennsylvania State University in preparing press material and hence this summary.

Efforts to meet this challenge—studies of how to make engineering education more effective—were the subject in every hall at the Pennsylvania State University used by the Society during the five-day annual meeting. Few ASEE conventions have been so clearly devoted to only one vital theme.

In his presidential address, the keynote of the meeting, Dean Nathan W. Dougherty called on teachers everywhere to bend their efforts to achieve excellence. "The average is too low," he said. "It must be elevated, and excellence must not be allowed to drift toward good enough." Specifically, said Dean Dougherty, "engineering education must be more than an assembly of many courses, lectures, and laboratory exercises." Educational objectives, he said, should be these: an ability to read and understand, to search and to find, and—above all—to have a love of learning. "Intellectual dolts do not go far in any field, intellectual sluggards may make some progress, but the lover of learning will learn what he needs to know whenever he needs it. Students should feel about education as did Mrs. Miniver about the new hat: 'It does something to me.'"

Final Evaluation Report

The final report on the Evaluation of Engineering Education, another feature of the general session on Tuesday, June 21, contained no revolutionary departures from the previous (1954) interim report of that committee. Basically, the recom-



(Penn State Extension Photo)

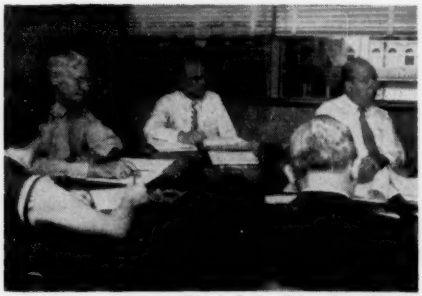
The principals at the 1955 annual banquet pose before entering the ballroom at Penn State; they are, in the usual order, Dean N. W. Dougherty, retiring president who was toastmaster of the evening; Charles E. Wilson, Secretary of Defense, principal speaker; Dr. Vannevar Bush, 1955 Lamme Medalist; and Dr. Robert R. White, Westinghouse Award winner.

mendations were for better understanding of the basic sciences, the engineering sciences, and the humanities and social studies, with less emphasis to be given to rote learning of practical engineering. "Specific details of engineering practice," said the report read by Dean Linton E. Grinter, chairman of the committee, "change too fast to be of value for classroom study except as they may serve the high purpose of illuminating fundamental, unchanging principles. If this criterion is applied rather forcefully by engineering faculties," the report continued, "it is felt that opportunity will be found within the usual time limits to increase basic studies in science and humanities."

As more is learned of the basic sciences, we in engineering have vast new areas for exploitation and new foundations upon which to build, said the committee. "The great changes in physics and chemistry over the past 30 years and the equally great advances in engineering practice do not seem to have produced an equivalent in a reorganization of engineering curricula."

To meet these challenges, the report of the engineering education evaluation committee recommended:

1. Staff members endowed with energy and enthusiasm combined with high technical ability that is applied in a creative manner must be encouraged in every possible way.



(Penn State Extension Photo)

The Executive Board in session: Dean Nathan W. Dougherty presiding over the Board's first meeting at Penn State Monday morning, June 20. At his left is the Society's secretary, W. Leighton Collins, and at the extreme right Dean W. L. Everitt, vice president.

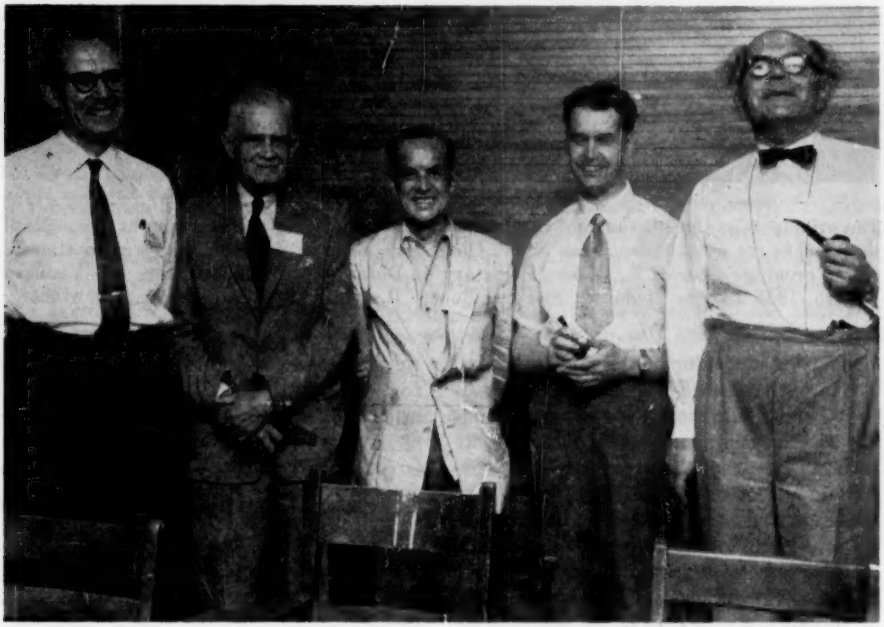
2. In general, the basic sciences—mathematics, physics (including nuclear and solid-state physics), and chemistry—should total about one-fourth of the undergraduate program.

3. To achieve breadth, quality, and penetration, about one-fourth of the total undergraduate program should be allotted to studying engineering analysis and design.

4. About one-fifth of the curriculum should be devoted to humanistic-social studies.

5. There should be electives amounting to about one-tenth of the total engineering program.

6. Graduate education, particularly relevant in engineering fields most closely



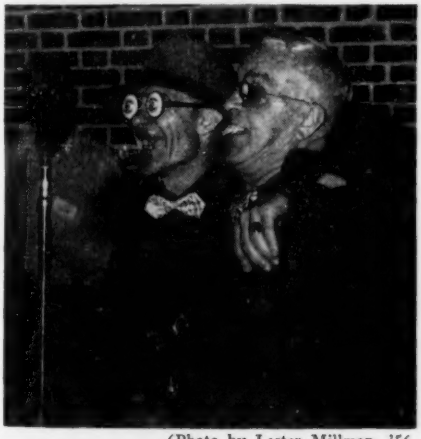
(Penn State Extension Photo)

These five foreign visitors were guests of the Society at the 63rd annual meeting: Professor Leon Christens of the Military College of Belgium, Brussels; LeRoy F. Grant, president of the Engineers' Council for Professional Development and a long-time leader of the Engineering Institute of Canada; John R. Whittaker, principal of the Technical College of Dundee, Scotland; M. Ove Guldberg, secretary of the Danish Engineering Society, Copenhagen; and F. M. Roeterink, adviser on educational affairs at Philips Industries, Eindhoven, Holland.

dependent upon scientific advance, should be devoted to the deepening of insight and understanding and to the development of the stronger intellectual and scientific foundations which are essential to real mastery of the field.

Special Studies of Humanistic and Graduate Work

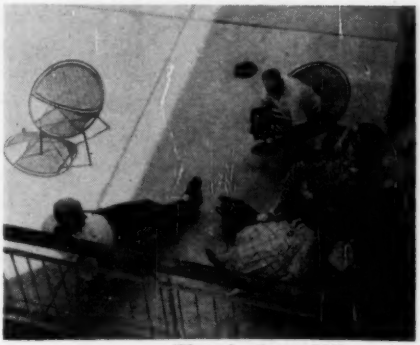
This final report on the Society's major undertaking of the past three years was accompanied by preliminary summaries from two other self-criticism study projects. Dr. Edwin S. Burdell, chairman of the Humanistic-Social Research Project, said in a preliminary report that his committee will reaffirm earlier recommendations for a "designed sequence of courses extending through the four undergraduate years," representing at least one-fifth of the undergraduate's total time. The matter of integrating these courses is a special problem; indeed, he said, the committee believes that "in the search for unifying concepts, engineering educators are struggling with the most difficult intellectual problem of our time."



(Photo by Lester Millman, '56, from the *Penn State Engineer*)

These two happy Pennsylvania Dutchmen are members of Schwab's Wagon Works Band, which entertained at "en Zammelaaf fer Mansleit, Weibsleit, un Kinner"* on Monday night.

* For those whose Pennsylvania Dutch is not up to this phrase, a literal translation: a get-together for men-people, women-people, and children.



(Photo by Lester Millman, '56, from the *Penn State Engineer*)

A shady corner on the terrace of the Hetzel Union was a welcome place to relax between sessions.

Dr. Ernst Weber, chairman of an *ad hoc* committee to plan a review of graduate education in engineering, said these five problems justify an intensive study, for which plans are underway:

1. The competition of industrial employers is taking many of the best candidates away from graduate school entrance.
2. Financial support available to graduate students, while apparently inadequate, may be diverting them from the most valuable educational activities.
3. The growth of industrial plans for part-time graduate study suggests the need for new safeguards of academic standards.
4. The spread of graduate work in engineering raises the question of institutions' competency to undertake this exacting educational program.
5. What special types of graduate training may be most appropriate for the more specialized demands of industry?

Broad Self-criticism

Together, these projects of self-criticism constitute a ferment in engineering edu-

(Penn State Extension Photo)

Young visitors spent busy mornings in the University Nursery School—here under the able guidance of Mrs. E. W. Lehmann, whose husband is professor of engineering research in the Ordnance Research Laboratory at Penn State.

cation which cannot be minimized. The session devoted to these reports was the heart of the 1955 meeting. The interest of national groups which have helped make possible these studies—including the Engineering Foundation, Engineers Council for Professional Development, the National Science Foundation, the General Electric Company, and others—speaks for itself. These are intensive studies, with many local committees, participating groups from related professional societies, and corps of field workers. Their impact may not be revolutionary, but it will be clear and long-lasting.

What, for instance, does industry say of these recommendations on engineering education?

"Every sentence of the evaluation report," said F. W. MacDonald of the Guided Missile Division, Firestone Tire and Rubber Company, "has potential energy capable of starting profound discussion. One must be content to say in different words that which has been said so well." John L. McLucas of Haller, Raymond and Brown, Inc., a small electronics research and development company, affirmed that from his point of view the proper equipment for an engineering graduate is a sound background in the basic sciences, an ability to communicate his ideas to others, and an inquisitive nature which will cause him to remain a student throughout his professional career. Speaking for the aviation industry, Vernon Outman of the McDonnell Aircraft Corporation emphasized that an engineering graduate should have "a basic descriptive understanding of a large number of subjects associated with the one in which he specializes."

John Gammell, director of graduate training at Allis-Chalmers Manufacturing Company, reported a survey of engineers' and industrialists' opinions. "Collectively, they indicate a need for adaptable people with broad educations. They emphasize, too, that college is but a prologue to a useful career. A good education is one that stimulates a man to continue growing in whatever direction is necessary."

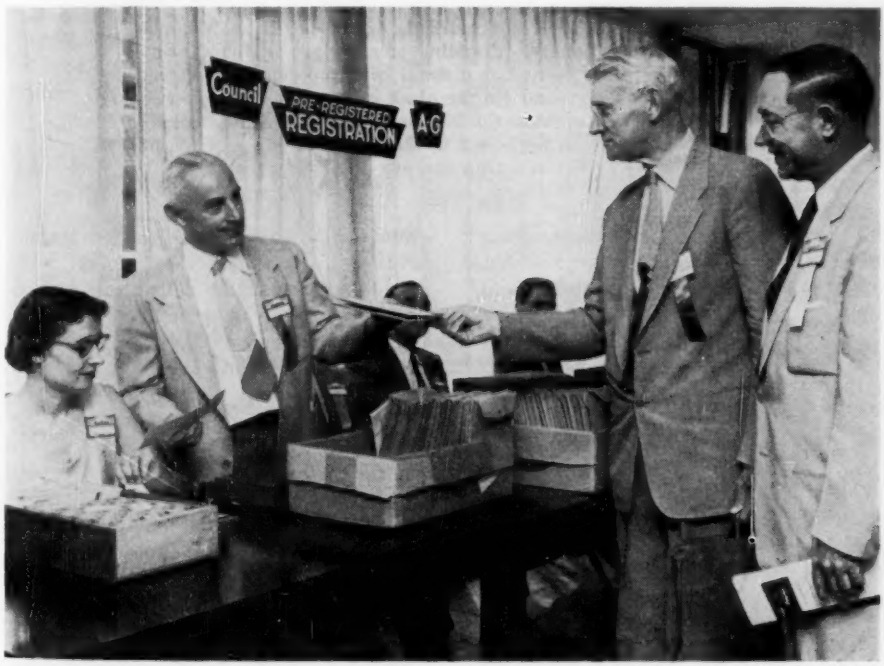
The research director who looks for new talent for his laboratories, said Chalmer G. Kirkbride, president of the Houdry Process Corporation, wants a graduate who can join a team with other highly trained engineers and scientists. "Too often, the graduate's training in school has neglected the ability to work in a team. Often, too, his training has been too much in the direction of robot in-

(Penn State Extension Photo)

The Society's new president is buttonholed in the union lobby by Dean J. F. Downie Smith of Iowa State College (left) and Professor E. E. Ambrosius of Penn State, who had charge of ASEE conference facilities for the local committee.

tellectuality—too much standardization, too much devotion to the assimilation of factual knowledge at the expense of learning how to think imaginatively." John K. Wolfe, manager of advanced degree recruiting at General Electric Company, reported a survey of the reaction to the interim evaluation report among G. E. engineers and public utility executives. Some of the responses, he said, suggested greater emphasis on the development of students' latent creative abilities—especially in the case of outstanding students who may be neglected because they seem to need help less than others. And some pointed out that with the introduction of the curricular changes proposed, the motivation of engineering students may become a problem: students will receive less actual engineering education early in their college years and may lose interest because little in their courses seems relevant to their final goals.

The study of the humanistic-social stem was anticipated by Dr. Jess H. Davis, president of the Stevens Institute of Technology, who asked for a sharpening of the objectives of such study in the engineering curriculum. These courses should be arranged, he said, so that we can more clearly compare their accomplishments with the objectives we set for them. Indeed, he suggested, we may "set aside the liberal arts tradition and attempt to create one of our own—a techno-humanistic tradition that recognizes and welcomes the influence of science and technology on our times and that attempts to learn from



(Penn State Extension Photo)

Registering the president: Dean Earl B. Stavely, head of Penn State's registration committee, hands his credentials to Dean Nathan W. Dougherty at the opening of registration for the 63rd annual meeting. Assisting is Mrs. Nancy Boodly, Penn State engineering drawing instructor, while Dean Eric A. Walker, whose only responsibility was the weather, watches confidently.

(Penn State Extension Photo)

Teen-agers enjoyed the usual pursuits of the beach at Whipple's Dam, near State College. Standing at the right is John Ditmar, State College's city recreation director, who supervised the outing; the girl in the foreground (in the black suit) is Kay, the daughter of Professor W. Leighton Collins, secretary of the Society; and the half-buried victim is the son of Professor Christian K. Arnold of Penn State, acting the role of perfect host.

the best of man's past and contemporary achievements how to make the wisest use of the new forces now at our command."

A Gracious Host

While intensive self-evaluation was the meeting's principal theme, it was not the members' only activity during five days at the Pennsylvania State University. From the moment of registration until the last suitcase was squeezed shut, the local committee under Dean Kenneth L. Holderman made every minute a pleasant one. Penn State proved to be a gracious host with a spectacular new union building as headquarters, commodious dormitories, good food, and a perfect high-altitude climate of bright days and cool nights. The meeting brought to State College a total of 1587 members of the Society and other professional delegates, with 779 members of their families—a grand total of 2366, the largest annual meeting in the Society's history.* The resolutions committee called the convention "one of the most notably successful and enjoyable in our history."

Full days were planned for everyone. Mrs. C. G. Reen and her committee established ladies' headquarters with a daily coffee hour and ran all-day excursions to Penn's Cave and Old Boalsburg, both flavored with Pennsylvania Dutch tradition. The teen-agers among the visitors soon established themselves in the "tub," Penn State's former (temporary) union building, and made a path to Whipple's Dam, a nearby state park with a fine sandy beach. The facilities of the University Nursery School kept the youngest

* The last meeting at Penn State (1939) set an attendance record which stood unbroken until the 1954 convention at the University of Illinois.

visitors happy, and separate events were planned for grade-school-age children.

Relations with High Schools

One entire general session was given over to the vital problem of attracting high school students to engineering and science. Dean J. F. Downie Smith of Iowa State College, citing the financial difficulties of most secondary schools and their inability to attract competent teachers in the sciences, called on colleges to work with high schools in helping to solve problems of joint interest. This would include, he said, help on providing the types of preparation most effective for college careers in science (but not to do this by a firmly enforced set of entrance requirements), financial aid to high school science teachers, help in guidance and "careers day" programs, and useful educational programming on radio and television.

Speaking of high school science fairs and science clubs, Dr. Watson Davis, director of Science Service, emphasized the value of actual experience in science. "The young person with talent often discovers himself," said Dr. Davis, "through the excitement and satisfaction of tackling a scientific problem experimentally." Encouraging science clubs and science fairs —"the science youth movement," Dr. Davis called it—is an important channel open to college and university people. Ray C. Smith, coordinator of engineering personnel at the Allison Division, General Motors, reported at another session on widespread industrial activities to encourage students in science and engineering. "But," he said, "this is more than a task for industry alone. It is a job for every mature citizen who is aware of the serious shortage of scientists and engineers which we now face—a shortage which is a real threat to the technological and economic future of our country."

(Penn State Extension Photo)

Dr. E. W. Engstrom, vice president for research and development, Radio Corporation of America, filled the Hetzel Union Ballroom on Tuesday evening, speaking on the qualifications industry seeks in potential research workers.

To encourage high school science may be one of the ASEE's principal purposes in the years immediately ahead. One valuable new tool in this work was demonstrated at Penn State: a 16 mm. sound and color motion picture entitled "Engineering—A Career for Tomorrow," sponsored by Eta Kappa Nu and designed for showing to high school audiences. The film, which seeks to show in teen-agers' terms how an engineer tackles a typical job and what he needs to fulfill his assignment, had a warm reception.*

Other Highlights

These other highlights of the meeting —frivolous and serious—were among those reported by the press room:

Their extensive research activities have qualified two more engineering colleges—University of Dayton and University of Virginia—for membership in the Engineering College Research Council.

Dr. Henry H. Armsby, chief for engineering education in the U. S. Office of Education, saw his birthplace for the last time during the convention. He was born in a little house almost directly across the street from the Hetzel Union at Penn State, and the house is soon to be razed to make room for a growing university. He will get the fireplace decoration, courtesy of Penn State.

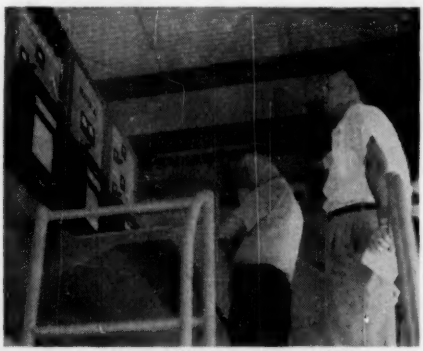
At its first session Monday morning, the Society's Executive Board heard Professor W. Leighton Collins, secretary, report the national membership at a new high of 7560. The Society's total financial operations for 1954–55 reached $85,640, also a new record high.

Special ceremonies were held during the convention by five technical institutes, charter members of a new non-profit foundation to "develop technical-institute-type education in the United States through mutual efforts of the independent, non-profit institutions." Karl O. Werwath, president of the Milwaukee School of Engineering and one of the signers of articles incorporating the new foundation, said it will "disseminate information about technical institute education, develop curricula and schools, and otherwise promote the interests of these institutions."

An early arrival in State College was Miss Nell McKenry of Pittsburgh. She was the Society's assistant secretary from 1918 until her retirement in 1948, and she spent the meeting shaking hands of old friends and (successfully) dodging the press room's cameraman.

The 1956 meeting of the Society will be Iowa State College, Ames, June 25–29.

An initial grant of $6000 from Arthur Williston, former director of Wentworth Institute, Boston, and of the School of Design and Technology, Pratt Institute, Brooklyn, was accepted by the General Council to begin a broad study of two-year technical institute education in the United States. Dean Dougherty, in announcing the plans, promised "a comprehensive study of the philosophy, fundamental concepts, services, and potential-



(Photo by Lester Millman, '56, from the *Penn State Engineer*)

Two ASEE visitors study the control panel of Penn State's new reactor, soon to go into operation. The ASEE's tours duplicated one a week earlier by President Eisenhower, who was Penn State's commencement speaker.

* Distribution of the film is being arranged through the Chicago Alumni Chapter of Eta Kappa Nu. Write to T. E. Farley, Room 301, Illinois Bell Telephone Company, 208 West Washington Street, Chicago 6.

(Penn State Extension Photo)

Dr. Maynard M. Boring (left), consultant on manpower at the General Electric Company, receives congratulations from his predessor, Dean N. W. Dougherty, upon his election as president of the Society.

ities of the technical institute form of education."

A new medal to recognize outstanding engineering college research will be awarded beginning in 1956 by the Engineering College Research Council. The annual award will be made on the basis of "achievements in and contributions to original research, research administration, leadership influencing the productive research of others, or the effective application of research results to the advancement of engineering education."

Although most Americans have not yet seen an atomic energy device, this country's peacetime nuclear industry is so well along that it has a pressing need for engineers who can aid in its development. Dean G. A. Hawkins of Purdue University said the industry's ranks are now being filled by engineers originally trained in other fields; the immediate need is for graduates with an aptitude for research, development, and design and a basic knowledge of nuclear physics and other associated fields. Students talented at such things as construction, operations, and sales will not be needed until later. H. A. Wagner of the Detroit Edison Company warned that "the need for nuclear engineers in the electric power industry will exceed the supply for at least the next ten years."

The Engineering College Research Council, reporting its biennial survey of American engineering college research, said that at least 20,000 teachers and their students—probably the largest number in history—are participating in a "strong and dynamic" program of research in engineering education institutions, a program valued at more than $110,000,000 annually. Dr. Harold K. Work of New York University said that "because of the research sponsored at American universities by government and industry, many engineering graduates today are better equipped than ever before to help themselves and their employers." More than 6500 individual research projects are tabulated in the Research Council's 1955 *Review of Current Research,* just off the presses.

Dean C. J. Freund of the University of Detroit reported for the committee on ethics, of which he is chairman, that nearly half of the country's engineering schools give their students lectures or conferences on general or engineering ethics. In another fifth of the schools, some less formal activity is used deliberately to bring the question of ethics to students' attention. The importance of this subject was stressed by Kenneth A. Meade, director of educational relations at General Motors Corporation, who declared, "The role of his profession places upon every engineer the serious responsibility of doing his work and directing his life according to the highest professional and moral standards that men of integrity can establish and achieve."

From the Young Engineering Teachers Committee came a proposal for a summer workshop, designed especially for teachers of less than five years' experience, to provide an organized program of prepara-

tion for teaching careers. Winners of YET awards for essays on engineering education were Harold A. Foeke of Notre Dame University (first place), Donald R. Lamb of the University of Wyoming (second place), and Edward J. Rising of Kansas State College (third place).

The Engineering College Research and Administrative Councils, at their combined banquet, heard Dr. E. W. Engstrom, executive vice president for research and engineering at Radio Corporation of America, list 10 qualities which industry seeks in its research workers: creativeness comes first, since the creation of new understandings, new principles, new products, or new services is indeed a definition of research; training in fundamental science is second only to creativeness; character—complete reliability in prosecuting a research program—is richly rewarded, yet "it is rarer than one might think"; vision is the fourth requirement: "creativeness coupled with vision to treat the creation objectively makes for greatness in research;" initiative and enthusiasm are the next in line of requirements, followed by scientific inquisitiveness and practical outlook.

Secretary of Defense Charles E. Wilson, principal speaker at the ASEE's annual banquet, pointed out that 50 per cent of the nation's scientists and engineers are now directly or indirectly working on national defense projects. "Our hope of peace," he said, "rests on our maintaining national strength during the years ahead while men of good will study ways to achieve international understanding."

In the News

"The colleges must join hands with industry in creating a good atmosphere for professionals to grow," urged N. W. Dougherty, Dean of Engineering at the University of Tennessee and Junior Past President of the American Society for Engineering Education. Speaking on the role of engineering education in engineer-industry cooperation at the 21st Annual Meeting of the **National Society of Professional Engineers** in Philadelphia, Dean Dougherty traced the development of engineering education since its introduction in the United States.

It is also the responsibility of colleges to produce a beginning engineer who will grow into ripe maturity and take his place in research, design, operations and management, said Dean Dougherty. He added that it was time that colleges taught their students the difference between a skilled workman and a professional.

Thanks to the recommendation of the ASEE Committee on Atomic Energy Education to the **Atomic Energy Commission**, Dr. Samuel Glasstone's "Principles of Nuclear Reactor Engineering" was published in August. The AEC approved the ASEE recommendation and hired Dr. Glasstone to prepare the sourcebook. Taking into account Dr. Glasstone's "Sourcebook on Atomic Energy" as a model, the Committee had recommended that he prepare the proposed text.

After the manuscript had been completed and reviewed by the subcommittee of the ASEE Committee, which was appointed specifically for that purpose, the Committee accepted the subcommittee's recommendation that Dr. Glasstone's text be accepted. The ASEE Committee feels that this book will be very useful in assisting engineering educators to incorporate nuclear materials into the engineering curriculum.

Summary of the Report on Evaluation of Engineering Education*

Engineering Education must contribute to the development of men who can face new and difficult engineering situations with imagination and competence. Meeting such situations invariably involves both professional and social responsibilities. The Committee considers that scientifically oriented engineering curricula are essential to achieve these ends and recommends the following means of implementation:

1. A strengthening of work in the basic sciences, including mathematics, chemistry, and physics.

2. The identification and inclusion of six engineering sciences, taught with full use of the basic sciences, as a common core of engineering curricula, although not necessarily composed of common courses.

3. An integrated study of engineering analysis, design, and engineering systems for professional background, planned and carried out to stimulate creative and imaginative thinking, and making full use of the basic and engineering sciences.

4. The inclusion of elective subjects to develop the special talents of individual students, to serve the varied needs of society, and to provide flexibility of opportunity for gifted students.

5. A continuing, concentrated effort to strengthen and integrate work in the humanistic and social sciences into engineering programs.

6. An insistence upon the development of a high level of performance in the oral, written, and graphical communication of ideas.

7. The encouragement of experiments in all areas of engineering education.

8. The strengthening of graduate programs necessary to supply the needs of the profession, conducted in those institutions that can:

   a. provide a specially qualified faculty,
   b. attract students of superior ability, and
   c. furnish adequate financial and administrative support.

9. Positive steps to insure the maintenance of faculties with the intellectual capacity as well as the professional and scholarly attainments necessary to implement the preceding recommendations. These steps include:

   a. well-established recruitment, development, and evaluation procedures,
   b. favorable intellectual atmosphere, reasonable teaching loads, and adequate physical facilities, and
   c. salary scales based on the recognition that the required superior faculty can be secured only by competitive remuneration, since professional practice in industry and government is inherently attractive to the best minds in engineering.

10. The consideration of these recommendations at this time before the problems of educating greatly increased numbers of engineers become critical.

* This project was financed in part by contributions from the constituent societies of ECPD, the Engineering Foundation, the General Electric Company, and the National Science Foundation.

Report of the Committee on Evaluation of Engineering Education

Objectives of Engineering Education and Their Implementation

Foreword

The Committee on Evaluation of Engineering Education of the American Society for Engineering Education (ASEE) was appointed in May, 1952, by President S. C. Hollister. This action followed a recommendation of the 1951 ECPD * Committee on Adequacy and Standards of Engineering Education and also followed discussions within the Engineering College Administrative Council of ASEE, the Education Committee of ECPD, and the General Council of ASEE. The charge to the Committee was to recommend the pattern or patterns that engineering education should take in order to keep pace with the rapid developments in science and technology, and to educate men who will be competent to serve the needs of and provide the leadership for the engineering profession over the next quarter-century.

The Committee on Evaluation began its work in June, 1952, at the Dartmouth meeting of ASEE. The Education Committee of ECPD immediately requested the Committee to give consideration to the development of standards that might aid ECPD in bringing engineering accreditation in consonance with future responsibilities of engineers. The Committee on Evaluation was asked particularly to clarify the curriculum content that differentiates engineering education from that in science on the one hand or in subprofessional technology on the other.

* Engineers' Council for Professional Development.

In order to enlist the aid of engineering educators throughout the United States in this important undertaking, the Deans of all engineering colleges having accredited curricula were invited to appoint Institutional Committees to conduct their own studies on evaluation of engineering education. A series of questions expressing the broad problems confronting engineering education was sent to these Institutional Committees to form the basis of exploration. The discussion of these questions by the Institutional Committees and the ASEE Committee culminated in the preparation of a series of institutional reports and in the Preliminary Report on Evaluation of Engineering Education, which was issued in October, 1953.

This Preliminary Report was distributed for critical review to all colleges with accredited engineering curricula. The response of the institutions was extraordinary and resulted in an extended analysis that was nation-wide in scope. Reports embodying the criticisms which developed were received from 122 Institutional Committees. Study of these recommendations by the main Committee aided it in understanding the nation-wide thought of engineering educators. Many of these recommendations and those expressed in the previous evaluation studies outlined in Appendix A, together with those of the Committee itself, formed the basis for an Interim Report on Evaluation of Engineering Education published in June, 1954. Critical review of the Interim Report was sought and obtained. All institutions were asked to review the Report and submit criticisms. Several hundred copies were mailed to as many industrial concerns with requests for criticisms.

Over eight thousand copies of the Interim Report were purchased in the first four months, which indicated both the wide interest of faculties in the Report and the extent of its distribution. It was also placed in the hands of all ASEE members by publication in the September, 1954, *Journal of Engineering Education.*

From the comments received from individuals, Institutional Committees, industrial companies, and societies, the Committee has concluded that the Interim Report has been accepted as pointing the trend for the evolution of engineering education over at least the next decade. Hence, this final Report follows basically the same line of development as the Interim Report. However, the comments received indicated two weaknesses that are believed to have been remedied.

First, the Interim Report failed to give adequate emphasis to the graduate phase of engineering education. This weakness has been corrected by expanding the former section on graduate work. However, since this new section in the final Report deals only broadly with graduate study, it is recommended that those interested in the details of graduate education refer to *A Manual of Graduate Study in Engineering,* published in 1945 as an ASEE Committee Report (*Journal of Engineering Education,* Vol. 35, p. 650) and reissued in 1952 in monograph form.

Secondly, comments which were received, particularly from industry, placed great emphasis upon the inability of engineers to express themselves in clear, concise, effective, and interesting language. Stress was also placed upon the importance to engineers of an acquaintance with the humanities and social sciences. This has led the Committee to reconsider the place of non-technical studies in an engineer's education, with the result that this final Report places greater emphasis on humanistic and social study and effective communication. Since a special investigation of humanistic and social studies in engineering education is being conducted by another ASEE committee, the subject is treated broadly rather than in detail in this Report.

Studies were also made and comments received from committees appointed by other societies at the request of the Committee to consider the teaching of physics and of mathematics to engineers. The American Association of Physics Teachers (AAPT), the American Institute of Physics (AIP), the Mathematical Association of America (MAA), and the ASEE Divisions of Physics and Mathematics all had committees participating in these studies. Although only one of these was a joint committee, the others served this purpose because of the overlapping membership involved and the joint meetings scheduled. The ASEE requested the National Science Foundation to support various conferences in these areas. Its generous response in supplying the needed funds and the enthusiastic cooperation of the committees involved made additional comments available which assisted the Committee in formulating the revisions incorporated in this final Report.

The Committee expresses its appreciation to the Engineering Foundation, the constituent Societies of ECPD, the General Electric Company, the National Science Foundation, and the General Council of ASEE for the financial assistance which made this study possible.

Objectives of Engineering Education

The determination of the pattern which engineering education should take in the future must, of necessity, be based upon the obligations of the engineering profession to society and upon the importance of the development of the student as an individual. The obligations of an engineer as a servant of society involve the continual maintenance and improvement of man's material environment, within economic bounds, and the substitution of labor-saving devices for human effort. Moreover, his activity usually has a direct bearing on the welfare and safety of large segments of society. Like the physician,

the engineer must work within the current limitations of the state of his art and must decide which one of several possibilities provides the best solution to a given problem.

Engineering is far from static, for it is essentially a creative profession. It has played a dominant role in building American industrial superiority, in developing the principle of mass production, and in giving the American people their high standard of living. The continuing growth of our knowledge of basic science has opened vast new areas to engineering endeavor and has enlarged the foundations underlying many of the existing engineering fields. Some fields of engineering have been reasonably alert in assimilating new scientific advances into their teaching programs. It is one purpose of this Report to encourage *all* fields of engineering education to move in this direction.

Any attempt to specify the content of an engineering curriculum must be preceded by the development of a clear understanding of the objectives of such professional education. These objectives are two-fold and are based on the technical and social responsibilities that must be assumed by graduates expecting to enter the engineering profession. The entire professional educational process is more inclusive in scope than an undergraduate engineering curriculum, for it also includes training in high school and post-baccalaureate study in a university or in industry, along with continual self-study and with experience in engineering practice before full professional status can be achieved.

Technical and Social Objectives—The first objective, the technical goal of engineering education, is preparation for the performance of the functions of analysis and creative design, or of the functions of construction, production, or operation where a full knowledge of the analysis and design of the structure, machine, or process is essential. It also involves mastery of the fundamental scientific principles associated with any branch of engineering, including a knowledge of their limitations and of their applications to particular problems, such as the development of materials, machines, or structures as well as the ability to make critical scientific and economic analyses and to organize these into clear, concise, and convincing oral or written reports.

The second objective, the broad social goal of engineering education, includes the development of leadership, the inculcation of a deep sense of professional ethics, and the general education of the individual. These broad objectives include an understanding of the evolution of society and of the impact of technology on it; an acquaintance with and appreciation of the heritage of other cultural fields; and the development of both a personal philosophy which will insure satisfaction in the pursuit of a productive life and a sense of moral and ethical values consistent with the career of a professional engineer.

These technical and social objectives should be met in a manner which will provide the individual with an enlightened background that will give him the means and the inspiration to grow on his own initiative before and after graduation. An undergraduate curriculum must serve a two-fold purpose of preparing some men for immediate employment and others for graduate study. This Committee believes that in any one field a curriculum with a reasonable degree of flexibility, as represented by electives, can meet both of these needs.

Implementation of Objectives

A number of factors influence the effectiveness of engineering education. Of these, the selection and development of a faculty and the relation of the curricular content to the objectives of engineering education have received the greatest emphasis in the nation-wide discussions that have taken place, and they form the central theme of this Report. Admission requirements, high school-college articulation, existence of adequate facilities, pro-

vision for gifted students, and the significance of graduate programs are also considered for their effect on the implementation of any suggested changes in present programs. Nevertheless, thoughtful consideration inevitably leads to the conclusion that the character and quality of the faculty are of controlling importance. Therefore, the selection and development of the faculty is considered first.

The Selection and Development of an Engineering Faculty

Distinguished faculties are far more important to the advancement of engineering education than details of curricula or magnificence of facilities. The university is a community of scholars and as such requires outstanding teachers to attract outstanding students. To improve and develop courses or curricula, to build up facilities—in short, to command respect as an educational institution—all require a faculty of competent teachers and scholars.

A thoroughly competent faculty can be acquired and maintained only if the college administration gives discriminating attention to the important problems of recruitment, selection, training, advancement, and termination of appointment. Logically, however, the selection of competent staff members can be undertaken only after long-range curricular objectives have been formulated.

University and College Environment

The academic and professional development of an engineering faculty can proceed only in a favorable environment. More important than physical surroundings is the intellectual atmosphere; that is, the attitudes and ideas of the people who comprise the university. A common inner urge to know and to understand is basic to this atmosphere and leads to unity of purpose—the mutual selection of common goals and coordination of effort toward their achievement. There must be encouragement of intellectual growth and opportunity for professional development such as is involved in the teaching of graduate courses. Teaching loads must be kept at reasonable levels to allow time for scholarly or creative activities. The development of such a favorable academic atmosphere should be the concern of all faculty members, particularly those in senior administrative posts.

Physical surroundings also contribute to a favorable environment. Facilities may be modest or extensive, as long as they are in harmony with and effectively serve the curricula. Besides adequate classrooms and laboratories, the individual teacher needs appropriate office space, research facilities, technical services, secretarial help, and an effective library. An adequate library, its accessible location, and its required use are essential elements in any educational process.

The atmosphere of a university has a significant influence on student progress. Students need a close bond of mutual interest and friendship with members of the faculty. They need objective guidance and encouragement in their intellectual growth; they need sympathetic understanding of their personal problems; but above all, they need the realization that they are being treated as individuals. An administration and a faculty which are genuinely concerned with these responsibilities are most likely to create a favorable student environment.

Qualifications of Teachers

Any teacher at the university level must have notable intellectual capacity and a sustained interest in a life of study for continuing mastery of his field—obvious qualifications that nevertheless merit explicit statement. To teach well, he must know and understand, clearly and in perspective, his own and supporting fields at a much more penetrating level than that required in his lectures.

The enginering teacher, in addition, must have a full appreciation of the goals to be achieved. He should realize, first of all, that a course can be taught either

as a narrow specialty or as a liberal subject in a professional curriculum; he should strive for the latter. Such a liberal course is one in which the teacher inspires his students toward creative endeavor and intellectual development not only while they are in college but also throughout their careers. It is one into which he brings recognition of the importance of intellectual honesty and professional integrity. To achieve these goals he should possess energy, enthusiasm, and a sincere interest in the development of men. To be fully successful he must exercise judgment and tact, and have the ability to meet the minds of his students. *He should perform creative work whether it be in teaching, writing, research, or professional activities.*

The selection of individuals for faculty appointments requires a careful evaluation of their qualifications. Good teachers have always been personally creative and capable of inspiring their students to creative endeavor. In the past they necessarily emphasized the art or practice of engineering. However, during the lifetime of present faculties the art of engineering has come to depend greatly upon basic and engineering science. It must also be recognized that universities are better equipped to teach the science underlying professional practice, whereas industry is better adapted to provide experience in practical applications. Within a faculty there should exist a balance of experience in both the science and the art of engineering.

Education and Experience

For a relatively young candidate for a faculty position, the strongest evidence usually available to measure a background of integrated fundamental knowledge and probable creative ability in teaching and research is an education which includes the doctor's degree. However, unless an academic environment is provided that will stimulate and retain men with an interest in creative work, mere insistence on degrees will not insure high quality in a faculty. For experienced persons, evidence of the capacity of the individual for creative teaching and research may be gauged by other criteria, and the formal educational background is of less significance.

Young engineering teachers who hold only the bachelor's degree should be employed only in a temporary position that presupposes a continuation of their education. Lack of such progress should be sufficient reason for terminating their appointments.

Appropriate professional experience in industry, government, or private practice is important in a well-balanced faculty. This experience should be considered in the selection and advancement of individuals, but it need not be a requirement for faculty members with a special educational background or with demonstrated creative ability in research or teaching. Every teacher, regardless of his background, should strive to become a recognized expert in his field. There is no substitute for knowledge of subject matter far beyond the limitations of that to be taught. However, it is recognized that mastery of subject matter alone will not guarantee good teaching and that neither industrial experience nor advanced degrees are adequate criteria in themselves. The minimum essentials for good teaching are the mastery of subject matter and the capacity of the teacher to draw students into active participation in the learning process. Strong individuality is often characteristic of distinguished teachers, but the capacity to cooperate with colleagues in carrying out the institutional program as a whole is nevertheless of great importance. The special qualifications of teachers participating in the graduate program are referred to in the graduate section of this Report.

Recruitment of a Faculty

Of paramount importance to any profession is the personnel of that profession. No time can be spent more profitably by administrative officers than that required for recruiting and developing competent

teachers. Recruitment of a faculty embraces the search for persons whose abilities, aptitudes, and personalities are of the desired type; telling them of the opportunities, environment, obligations, and limitations of the profession; ascertaining whether their ideals and ambitions are consonant with those of the profession and the school; and, finally, arranging suitable compensation for and other terms of employment.

New teachers are often recruited from among those students who have just finished study of a part of the wide field of engineering and science. It is recommended that promising undergraduate and graduate students be sought out and their aptitudes as potential teachers be appraised early in their schooling. If a student's interest is aroused in a teaching career, his study may be guided to embrace breadth of view and scholarly attitude. Such a program should help to recruit and develop teachers who will carry the responsibility of improving engineering education to meet the needs of the future. Care should be exercised to avoid excessive inbreeding: *heterogeneity of faculty backgrounds is inherent in the very concept of a university.*

The effective recruitment and retention of a qualified faculty will require, in colleges of engineering, the establishment of a salary scale comparable to the income earned by outstanding practicing professional engineers as indicated by the published surveys of national societies. Accepted practices in establishing adequate faculty salary scales in the professions of medicine and law indicate that competitive situations must be met if professional education is not to stagnate. It should be recognized that, in contrast with the situation in many academic fields, industry is inherently attractive to many of the best engineering minds. Unless the salary differential is minimized, a sufficient number of superior engineers will not be attracted to or retained in the teaching field, to the detriment of the whole profession, of industry, and of the nation.

In faculty recruitment, industrial or other experience is an important measure of professional qualification. However, one needs to look very closely at the nature and character of this experience to determine its relevance to engineering teaching. Of greatest significance is not the number of years of experience, or even the administrative responsibility that the individual may have carried, although these are not unimportant, but rather evidence of the use of intellectual qualities in professional practice, such as creative design or development, including patents, and research contributions involving reports and publications, or other experience of an analytical or creative nature. One might appropriately ask the following questions. Can the potential teacher articulate his engineering work with the underlying basic science and engineering science? Has his work been such that it has kept his background of science alive or, better yet, in continuous development? Many practicing engineers achieve results by the use of a kind of intuitive sense which, no matter how successful in practice, cannot be transformed into organized knowledge that can be taught to engineering students.

Development of a Faculty

Even though the environment and salary scale of an engineering college may be such as to attract and retain an outstanding faculty, the newer members of such a group will usually need guidance in the techniques of teaching. Their study of the ASEE Report on the *Improvement of Teaching* (*Journal of Engineering Education*, Vol. 43, No. 1, Sept., 1952) should greatly enhance the effectiveness of their teaching. The primary purpose of an engineering college is to provide effective instruction in subject matter through the stimulation and motivation of students, and it is essential that those selected to teach be trained properly for this function. Such instruction may be made more effective by proper organization of subject matter, by teaching elementary as

well as advanced courses in a given field, and by teaching subjects in related fields. *The teacher's own use of and insistence on the student's use of clear English, both oral and written, should be considered as an essential part of his teaching of any subject.*

Although experienced teachers will generally perform more effectively than young instructors or graduate assistants, it is possible to achieve excellent results with the latter. Graduate student teachers usually bring into the classroom a youthful vigor, an enthusiasm, and a fresh point of view that are highly commendable. They may also lack professional judgment and maturity to such an extent that they may not give the undergraduate student a sufficiently balanced kind of teaching. However, with careful selection and supervision of assistants and through course organization it is possible to provide competent instruction by teaching assistants. The teaching assistant must accept a responsibility as great as he would have in industry and should be asked to recognize his teaching job as a principal occupation, along with that of graduate study. Furthermore, teaching is a beneficial part of the educational experience even for those who later elect industrial pursuits.

Seminars, discussion groups, formal and informal conferences between experienced and inexperienced teachers can all be used effectively for the development and growth of a faculty. Informality in such arranged programs has merit so long as it does not lead to irregular participation. To maintain interest, such programs must be varied in form from semester to semester.

It is important that faculty members set an example for their students by their membership and active participation in professional and technical societies, by becoming licensed engineers, by study of current literature, and by demonstrating interest in new developments and in research. Such leadership among faculty members is particularly necessary in institutions that are able to provide only limited opportunities for research, for leadership contributes an important element of vitality to teaching. The spirit of leadership that also creates in the student a desire to lead is of the greatest importance. It can be developed by teachers who are men of stature, judgment, wisdom, and tact. The ambition for leadership should involve ascendence in a technical field and a desire to serve society.

In engineering teaching, continual contact with the forefront of engineering and scientific progress is essential. Leadership in scientific and engineering progress has frequently stemmed from university research activities. *The engineering teacher carries a responsibility to contribute to the advancement of knowledge through engineering research. The university must provide the opportunity to realize this objective in terms of time, facilities, and assistance.*

It is only when teachers of professional subjects are recognized as experts that they have an opportunity to do consulting work. Hence, the ability to engage in such consultation is not considered to be a major factor in the recruitment of young teachers. Consulting practice should be considered as a means of developing and further strengthening an engineering faculty. Close association with engineering work or research in industry should stimulate the teacher and improve his teaching. Consulting is also a source of ideas for research. The limit upon the useful extent of this activity has not been determined. However, the belief is widely accepted that an average of one day per week of the individual teacher's time devoted to consulting activity of a high professional character will reflect to the overall advantage of the institution.

Evalution of a Faculty

Evaluation of the potential of prospective faculty members and of the achievement of the existing staff ranks with the development of a progressive atmosphere as a most important function of a university administrator. Systematic and regu-

lar methods of evaluation rather than haphazard ones are essential as a guide for recruitment and for making salary adjustments and promotions. Definite policies on termination of appointment for those who do not live up to their expected performance are also necessary for proper development of a strong faculty.

It would be most desirable if this evaluation could be done on a quantitative basis, but the Committee is not aware of any systems which warrant recommendation for general adoption. The Committee suggests that there be more experimentation by individual institutions in the development of quantitative systems of faculty evaluation. Any evaluation system can serve only as a partial guide, since personal judgments must remain the most important factor. The Committee recommends that such quantitative systems as are developed be reported at meetings of the Society and in the Journal. The success of some industrial evaluation systems indicates that there is hope for progress in this area.

The fact that evaluation of the progress of a faculty member must be based on judgment involving many factors indicates that administrators at each level should inform themselves of the viewpoints of their faculties before reaching these judgments, realizing that there are dangers in judgments made by associates of the individual concerned. In particular, the faculty should be informed as completely as possible concerning the methods used in evaluation.

Evaluation, to be effective, should be objective, and it should include along with other factors all the items mentioned in the section on Qualifications of Teachers, with emphasis upon:

1. The effectiveness of the individual's teaching based upon his knowledge of subject matter, intellectual capacity, judgment, professional and personal stature, and qualities of personal leadership as shown in his ability to inspire students.

2. His productivity in research and other creative areas including new methods of presentation of subject matter.

3. His professional development as evidenced by progress in early years toward advanced degrees, by accomplishments in engineering practice, or by attainments and recognition as a scholar in his field.

4. His significant publications.

5. Evidence of his professional interest as shown by his activity in professional societies and in governmental and community affairs, and by his registration as a professional engineer.

6. The nature and responsibility of his consulting services to other areas of the university and to outside organizations.

It is important that administrators periodically advise members of the staff regarding their standing, particularly those members who should be encouraged at an early date to abandon a teaching career. Mere lack of promotion or of salary advances should not be assumed as a sufficient method of criticism for individuals who are not developing according to the standards expected.

It is equally important to stimulate the good teacher by verbal or written approbation, either for his general progress or for his special accomplishments. *It is essential that those staff members endowed with energy and enthusiasm combined with high technical ability that is applied in a creative manner be compensated in the fullest measure.*

An adequate staff either in a departmental faculty that is responsible for a curriculum or in a major supporting group will have at least one teacher in every five who has attained professional distinction. Such individuals will (1) be conducting high-grade research of an engineering or educational nature, or other creative activity, including publishing work of good quality, (2) be engaged in consulting work at a creative level, (3) be exercising leadership in scientific, educational, and professional societies, or preferably, (4) be serving in a combination of such activities.

Curricular Content as Related to the Objectives of Engineering Education

Instructional Goals

The ultimate goal of engineering education is the development of able and responsible men fully competent to practice on a professional plane, especially those who will eventually lead the profession to new heights of accomplishment through creative practice or research. The student, not the curriculum, is the primary concern, yet the curriculum has an important influence on education. Before considering curricular components, the instructional goals toward which they are directed should be examined.

The instructional goals of engineering education include helping the student to learn to deal with new situations in terms of fundamental principles, on his own initiative, with confidence and sound judgment. The goals should include motivation to keep abreast of the new developments in science and technology and to continue to grow intellectually in both professional and cultural areas throughout life.

In professional engineering practice the "new situation" often involves social and economic as well as technical elements, and these are not entirely separable. Thus the end result is not merely the numerical solution of a technical problem but is rather a decision based on a value judgment to which the quantitative technical result contributes one important element. In fact, the significant problems involving engineering seldom occur in well-defined form. Hence, the initial stage of thinking is often an intuitive groping to identify specific component problems. Their solution, in turn, requires the application of thoroughly understood fundamental principles and well-ordered analytical thinking in defining the problem, planning its simplification without losing its essential nature, conceiving a method of attack, carrying the study through to a successful conclusion, and checking the results at each stage. This technical solution is then available to guide the engineer when he considers the broader social and economic aspects of the problem. His final decision will be influenced by the extent to which his perspective and judgment transcend purely technical matters.

Engineering educators must never lose sight of the broad issues with which large engineering problems are always associated, although the ability to deal effectively with such broad issues comes only with experience and maturity in the years after college. The importance of keeping such economic and social ideas before students by example can hardly be over emphasized. Such concepts should be encompassed even though the main effort at the undergraduate level is largely restricted to developing the student's ability to master the scientific and technical aspects of engineering education. In what follows, therefore, these disciplines are emphasized even though they are but a portion, although a vital one, of the total education that the successful engineer acquires in college and throughout his subsequent professional career.

Assimilating New Scientific Material

The evolution of engineering curricula has been characterized by a continuous process of assimilation of new scientific and technological knowledge. Such innovations have necessitated the development of new concepts or shifts to more fundamental and scientific approaches. It seems evident that the frontiers of science and technology are now advancing at a more rapid rate than at any previous time, and that many of today's frontiers will be reduced to significant engineering practice in the years ahead. Furthermore, these newly developed frontiers illuminate the older fields with new concepts and give them increased vitality. It is a responsibility of the engineer to recognize those new developments in science and technology that have significant potentialities in engineering. Moreover, the rate at which

new scientific knowledge will be translated into engineering practice depends, in a large measure, upon the engineer's capacity to understand the new science as it develops.

This translation of new scientific developments into engineering practice will be facilitated by emphasizing unity in scientific subject matter. For example, there is a great deal of similarity, both in conceptual undertanding and in analytical methods, among the generalizations of heat flow, mechanics of fluids, electromagnetic fields, and vibration theory. When a student understands these generalizations, he has gained a concept of systematic orderliness in many fields of science and engineering; he is therefore able to approach the solution of problems in widely diverse fields, using the same analytical methods. This unification of methods of analysis can be accomplished to a considerable degree without reaching beyond undergraduate mathematical levels. It can be accomplished to a much greater degree by utilizing advanced mathematical concepts.

Breadth of Engineering Education

Looking at the subject of instructional goals even more broadly, one concludes that the engineer should be a well-educated man. He must be not only a competent professional engineer, but also an informed and participating citizen, and a person whose living expresses high cultural values and moral standards. Thus, the competent engineer needs understanding and appreciation in the humanities and in the social sciences as much as in his own field of engineering. He needs to be able to deal with the economic, human, and social factors of his professional problems. His facility with, and understanding of, ideas in the fields of humanities and social sciences not only provide an essential contribution to his professional engineering work, but also contribute to his success as a citizen and to the enrichment and meaning of his life as an individual. Hence, instructional goals include motivating students and providing them with stimulating opportunities to gain understanding and appreciation of our historical and cultural heritage. This requires that the faculties of the humanities and the social sciences regard the teaching of engineering students as challenging and rewarding, and that engineering faculty members adopt an appreciative and understanding attitude toward their colleagues in the liberal arts.

It is clearly recognized that many engineers progress into managerial and top executive positions in industry and government. For such individuals the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build. This foundation may be built more solidly in humanistic and social courses than in highly applied studies in management.

Education for the profession of engineering does not stop with the acquisition of a degree; it must continue throughout life. Hence, one of the significant instructional goals of engineering education is to motivate the student to learn on his own initiative.

Curricular Areas and Content

The preceding discussion of instructional goals clearly indicates that certain curricular areas are obviously basic to undergraduate engineering education. These areas include mathematics and the basic sciences, the engineering sciences, the application of these sciences to the analysis and synthesis of engineering systems within the student's major field, technical courses outside his major field, and humanistic and social studies.

The following paragraphs describe briefly the more important components of an engineering curriculum and give a rough indication of the broad curricular content and approximate level that appear to be appropriate to an undergraduate curriculum. ***These paragraphs are not intended as a statement of rigid require-***

ments, since the Committee recommends widespread experimentation. However, significant departures from these recommendations should be accepted only on the basis of clearly stated educational objectives.

The Basic Sciences

The basic sciences which make up the foundation of engineering curricula are usually considered to include mathematics, physics, and chemistry. These studies and the level of instruction contemplated in each are discussed below. ***In general the basic sciences will total about one fourth of the undergraduate program.***

Mathematics—Casual persual of current professional journals is sufficient to show that all branches of engineering are continually becoming more dependent upon mathematics of an increasingly high level. In fact, engineering judgment is more and more often guided by mathematical analysis, and such analysis is rapidly expanding the demands it places upon advanced areas of mathematics. At the undergraduate level, competence in the theory and use of simple, ordinary differential equations and their application to the solution of physical problems lies close to the boundary of *minimum* acceptability of mathematics in any satisfactory engineering curriculum. For students who will be chiefly interested in research, development, or the higher phases of analysis and design, or who contemplate subsequent graduate study in engineering, additional mathematics may be both desirable and necessary.

A minimum level of performance in mathematics should be established, whether it be obtained in required mathematics courses or in engineering courses. However, few engineering courses are taught in a manner to make a significant contribution to the student's knowledge of basic mathematics, nor is time available for this purpose. The engineering sciences and subsequent professional subject matter should be developed by making effective use of such mathematical proficiency and should be taught by staff members who have this proficiency.

Physics—Too often, physics as presently taught to engineers barely touches upon the many new physical concepts which have been developed during the past generation and which today strongly influence engineering practice. ***Modern physics, including an introduction to nuclear or solid-state physics, should be a part of undergraduate engineering curricula.*** As a contribution to making this presentation to engineers as effective as possible in a limited time, it is believed that the basic course in physics needs a new orientation. The duplication between classical physics and the engineering sciences of mechanics, thermodynamics, and electricity can be largely removed if the objective of the introductory physics course is redirected to place much greater emphasis upon sub-microscopic phenomena and the conservation principles, with virtual elimination of semi-engineering examples. An introductory course in physics that attempts to be a tool subject for engineering mechanics, thermodynamics, and electricity appears to serve less and less purpose. When engineering colleges request physics departments to present an introductory course in atomic physics for large numbers of engineers, it seems evident that the introductory physics course will then have to be remodeled to provide the strongest possible background for this new objective.

Chemistry—Chemistry should include topics in inorganic, organic, and physical branches presented in condensed and general form. The initial study must prepare engineers to enter advanced courses in chemistry and in its applications to such fields as properties of materials, metallurgy, fuels and combustion, corrosion, and industrial chemical processes. Hence, such subjects as rates and kinetics of chemical change, chemical equilibria, phase diagrams, solutions, electrochemistry, and colloids should be included. Careful coordination should also be effected between modern physics and chemistry. For stud-

ies beyond the usual freshman chemistry course it is felt that physical chemistry deserves the main emphasis.

The Engineering Sciences

An engineering science as defined here is a subject that involves largely the study of basic scientific principles as related to, and as related through, engineering problems and situations. Engineering science stems from two basic areas: mechanical phenomena of solids, liquids, and gases; and electrical phenomena. A common practice is to subdivide these into the following six engineering sciences:

1. Mechanics of solids (statics, dynamics, and strength of materials).
2. Fluid mechanics.
3. Thermodynamics.
4. Transfer and rate mechanisms (heat, mass, and momentum transfer).
5. Electrical theory (fields, circuits, and electronics).
6. Nature and properties of materials (relating particle and aggregate structure to properties).

It is not necessary that this material be treated as separate courses. Experimentation should be encouraged to find the best way of achieving, with the available staff, the desired goal in a specific environment. It is not intended that the above shall be a complete list of the engineering sciences. *It may be anticipated that other engineering sciences will develop;* for example, information theory shows promise of contributing to measurement and control in all engineering fields.

Few existing curricula contain all six engineering sciences, despite wide agreement as to their basic desirability. It is evident that the engineer needs background in all of the six fields listed. Only after careful consideration and determination that the fundamental concepts are substantially covered in other studies at an equivalent mathematical level, should one of these engineering sciences be omitted from a curriculum. Alternately, there may be some curricula or engineering programs for which sciences other than those listed must be chosen, for example, a life science or an earth science. *It should be possible to achieve the breadth, quality, and penetration desired by allotting about one fourth of the total program to the undergraduate study of engineering sciences.*

In the study of engineering science, full use should be made of the mathematics, physics, and chemistry described in the section on Basic Sciences, recognizing that some repetition is a normal pedagogical necessity, but that it can be most effective only when consciously and purposefully used. Perhaps nowhere else can the qualities of a scholarly engineering faculty be employed so effectively as in the presentation of the engineering sciences with an appropriate mathematical understanding.

The Committee is aware that many present curricula do not contain adequate content in each of these fields. The Committee therefore stresses its position that the requirements for engineering sciences suggested above, as well as the requirements in basic sciences suggested herein, represent not only desirable goals, but the actual trend of future education for engineers. The suggested requirements are not intended to be taken as precise criteria for accreditation, although they are intended to be helpful in achieving higher standards for that purpose.

Engineering Analysis and Design

Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, development, and engineering research is the most distinctive feature of engineering curricula. Such education intrinsically stems from the case method of approach, rather than from an orderly exploration of a given subject-matter field. Some experience in this "design" function should be carried in an integrated manner through each semester of the last two years and may be begun earlier if practicable. *Approximately one fourth of the total undergrad-*

uate program may be appropriately devoted to engineering analysis and design, including the necessary technological background.

Among various mechanisms for implementing the case method are theses, projects, group operations, competition between groups, the use of realistic or unsolved problems, examinations on unfamiliar subject matter, and the synthesizing of a new device rather than the analysis of an old one. These case studies go far beyond and are quite different from routine repetitive features of practical design, the use of handbooks, or the description of structures, equipment, or machines, including their construction, operation, and maintenance. Such engineering art is learned more effectively from field experience than from college study. *The capacity to design includes more than mere technical competence. It involves a willingness to attack a situation never seen or studied before and for which data are often incomplete; it also includes an acceptance of full responsibility for solving the problem on a professional basis.*

This portion of many engineering curricula demands close scrutiny and continuing active change. The major department sequences in many instances are dull and uninspiring, utilizing practices long outdated. These are areas in which newly developed concepts, analytical techniques, and measurements should be brought to bear. They should be taught by men who are making active contributions to engineering progress. For example, courses in Internal Combustion Engines are often largely descriptive in nature, and hence are essentially sub-professional. They can be vital experiences in which the principles and advanced analytical techniques of mechanics of solids and fluids, thermodynamics, and heat transfer are used effectively; the nature of combustion, friction, and materials are considered; and creative thought and imagination are brought to bear in producing an integrated system. To do this is a difficult and challenging job, but a very necessary one. These observations apply with equal force to such subjects as Power Plants, Highway Engineering, Electrical Machinery, Chemical Processing, Extractive Metallurgy, etc., etc. It is important again to stress the necessity of utilizing fully in such studies the basic and engineering science training at the level which this report outlines.

Engineering Laboratories

The laboratory is the means of teaching the experimental method. It should give the student the opportunity to observe phenomena and seek explanations, to test theories and note contradictions, to devise experiments which will yield essential data, and to interpret results. Therefore, laboratories should be used where and only where these aims are being sought. The value of a set number of stereotyped experiments is questionable. The development of a smaller number of appropriate experimental problems by the students themselves under effective guidance will have much greater educational value.

The art of measurement—including analysis of accuracy, precision, and errors—and the appreciation of the degree of accuracy economically justified, together with some understanding of statistical methods, are essential elements of laboratory experience.

Laboratory reports, when restricted to a few per semester, present a major opportunity to develop skill in the written presentation of engineering information. Stereotyped reports are valueless in teaching the art of communication.

Non-Departmental Engineering Courses

Such courses as electrical engineering for non-electricals, heat engines for non-mechanicals, etc., should emphasize fundamental ideas and principles and methods, rather than special machines or devices. *The most important engineering background of the professional engineer, apart from his major field, lies in the basic sciences and the engineering sciences.*

The study of engineering materials, in-

cluding laboratory testing, is often scattered through several courses and can be coordinated to advantage. Increasingly, forward-looking engineers are searching the recent advances in solid-state theory and chemistry for an entirely new and fundamental scientific approach to the study of the behavior of materials. This field appears to be almost ready for engineering conquest, and its development will bear very close watching by engineering educators.

Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful for these purposes is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, and the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work. Though the engineer may only supervise the preparation of the drawings required to execute his designs, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with graphical communication.

Shop courses and all other courses emphasizing practical work that tend to displace engineering science in the curriculum should be scrutinized critically in the light of the instructional goals already discussed.

Humanities and Social Studies

The goals of engineering education already outlined require for their achievement adequate attention to subjects in the humanistic and social fields. In addition to technical knowledge and skill, the professional engineer needs to have some acquaintance with the subject matter of fields other than his own, with their influence upon the lives of men, and with their relationships to his own profession.

If the student is to be provided with a foundation upon which he may build a career of professional stature, his education must help him to seek his fullest development as an individual. This involves stimulating his imagination, instilling a respect for learning in all its forms, and creating an awareness of the great variety of ways in which man has sought order and meaning in the universe. College experience should facilitate the student's growth in ability to perceive significant relationships, to make intelligent value judgments, to express himself with ease, clarity, and good taste, and to develop the qualities of character and personality requisite for a successful career.

To the attainment of these objectives both the technological and the humanistic divisions of the curriculum should contribute as integral parts of one total program. It is a mistake to look upon technology alone as the productive component of the student's development and on the humanities as providing only the liberalizing elements in his pattern of growth. On the contrary, all of his courses of study, whatever their specific objectives in knowledge or skill, should be so designed and taught as to contribute toward the student's development as a truly educated man whose convictions, understandings, manner, and speech are intimately related components in the fibre of his life.

To serve most effectively their objective of giving breadth to the student's understanding of the world in which he lives and of awakening his interest in the great ideas that have evolved during man's struggle toward a better civilization, courses in the humanities and social studies should help the student to arrive at a satisfying personal philosophy rather than to provide him merely with immediately useful technical knowledge and skill.

Selection of Courses—The fields of humanities and social studies from which some courses must be selected include history, economics, and government, wherein knowledge is essential to competence as a citizen; and literature, sociology, philosophy, psychology, and fine arts, which afford means for broadening the engineer's intellectual outlook. The Committee has

found no reason to disagree with the recommendations of previous ASEE Committees that *about one fifth of the curriculum should be devoted to humanistic and social studies.*

Such non-engineering courses as accounting, management, industrial finance, marketing, and personnel administration may well be valuable components of a particular curriculum, but being essentially technical in content, they do not adequately fulfill the main purpose of the program in humanities and social studies.

Motivating the student to learn on his own initiative is as much the aim in the humanities and social studies as it is in other parts of the curriculum. In the time available he cannot be expected to acquire a comprehensive knowledge of the subject matter of even one of the humanistic or social disciplines. He can, however, be given an understanding of the nature and function of some of the principal disciplines, together with an introduction to the methods of thinking likely to be most conducive to further growth in these fields within the life experience of the student. The courses should be designed to liberate him from provincialisms, whether geographical, historical, or occupational, and to give him a sense of the satisfactions that he can gain later in life by adventuring more deeply into the areas of critical and creative thought represented in the humanities and social studies. His capacity to make sound qualitative judgments should be developed so that he may distinguish that which is good from that which is mediocre.

English—A word must be said here about English, which is both utilitarian and humanistic. Facility in expression, written and oral, is a professional necessity and an overall personal asset. Knowledge of literature and the ability to read with sympathetic understanding are parts of a liberal education. English, therefore, has one root planted in the humanistic portion of the curriculum, another in the technological. For developing skill in English usage sufficient for the professional engineer, sole dependence upon specified courses is not enough. Adequate motivation is essential; it can be attained only by active efforts on the part of all teachers to point out the economic and cultural rewards which will accrue to engineers who develop skill in the art of verbal communication. This requires personal counseling and sympathetic understanding of the student's pre-college cultural background, as well as insistence on the highest attainable standards of performance in written and oral work in the engineering courses.

Realization of Broad Social Objectives—To realize the overall objectives of the undergraduate program, a reasonable portion of the curriculum, such as a sequence of courses throughout the undergraduate years, should be allotted to formal courses in the humanities and social studies. But this, in itself, is obviously not enough. Members of the engineering faculty can make their own contributions to the general education of their students by precept and example, by their attitudes toward the work of colleagues in fields other than their own, by their support of the various extra-curricular activities that help so much in the maturing of an undergraduate, and by being themselves responsive to a broad range of cultural interests. An engineering faculty member who disparages the value of humanistic courses can hardly expect students who look to him as their ideal to enter upon such studies with enthusiasm.

Teachers on the liberal arts faculty should distinguish between the mission of developing scholars and conducting research in their own disciplines, on the one hand, and their obligation, on the other hand, to make available the knowledge and values that are significant for students majoring in other fields. This Committee believes that no effort to enhance the value of the humanities and social studies will yield greater returns than that devoted

to bringing about a genuine community of interest, better understanding, and more meaningful cooperation between teachers of engineering and those in the liberal arts. The whole field of engineering education is the joint enterprise of men in a variety of disciplines. For it to be effective and complete, they must respect and sustain each other.

Elective Courses

All too often present curricula leave no time for electives, either technical or humanistic. *The Committee believes that provision for electives should be made to an extent of about one tenth of the program exclusive of ROTC.* It also believes that there is an advantage in permitting some students to concentrate such elective study in science, while other students may choose electives largely in humanities and in social fields. The limiting of elective study to courses in the student's major engineering department is not consonant with the objectives being sought.

The Committee on Evaluation recognizes, as do most faculty members, that there is need for as much flexibility as possible within the framework of a given curriculum for each student to extend his own interests. Some choice may exist in the sequence of social and humanistic courses, in the later courses in mathematics and science, and in the departmental sequence of work in engineering analysis and design. However, it is primarily in elective courses that the student can best extend his interest toward his future professional activity. The objectives of engineering education are best satisfied when each student is given a free choice of options or elective courses, provided that the elected courses contribute to a planned objective.

Making Room for New Curricular Material

In this Report, several additions to curricula have been recommended without suggesting corresponding deletions. More emphasis on fundamental science, on engineering science, and on the broad humanistic and social areas has been recommended than is contained in most engineering curricula. This does not imply that the engineering student needs to be worked harder. Indeed there is considerable doubt as to whether there is any margin of student time left. Four possibilities for achieving these additional, important objectives are listed below. Each school, no doubt, will wish to choose its own methods, recognizing that those suggested are of varying degrees of practicability to each institution.

These four are as follows:

1. Raise the requirements for entrance. This might entail:
   a. More adequate high school preparation.
   b. Higher selectivity.
2. Increase the effectiveness of instruction.
3. Eliminate some of the material now in the curriculum.
4. Extend the curriculum to more than four years.

Much has been written about high school preparation. Continuing encouragement should be given to high schools to raise their standards and to give appropriate training to college-bound students, including engineering students. However, it is doubtful whether engineering educators can realistically entertain serious hopes for substantial gains from this source over any short period of time. One ray of hope lies in the summer programs for high school science teachers that engineering schools, with the cooperation of industry, have been offering. Although higher selectivity would permit a more rapid rate of academic progress, it would decrease the number of applicants at the very time when national welfare calls for the reduction in the present shortage of engineers.

Increasing the effectiveness of instruction is a process more or less continuously under study by many faculties. Newer, simpler ways of looking at complicated

phenomena and their analysis evolve continually in the minds of an alert faculty. Profound understanding of a topic is often accompanied by the ability to give a clear and simple statement. One contribution of our graduate schools to the development of undergraduate education should be a continuous simplification in methods of presentation of subject matter to undergraduates.

Elimination of Curricular Material—Elimination of material now in the curriculum, likewise, is an accepted practice in rapidly growing fields. Two kinds of material can well be looked at with a view toward possible elimination. Unduly repetitious material should be eliminated. Conscious repetition, carefully designed as a pedagogical instrument, may be used but not to the extent that it detracts seriously from student interest. Other areas due for close scrutiny, with a view toward possible elimination or reduction in time, are those courses having a high vocational or skill content and those primarily attempting to convey engineering art or practice. *Some attention to engineering art and practice is necessary, but its high purpose is to illuminate the engineering science, analysis, or design, rather than to teach the art as engineering methodology.*

A review of the evolution of engineering curricula over many years shows a trend toward increasing emphasis on the science underlying engineering at the expense of the study of engineering art for its own usefulness. This trend would appear sound for application in the present dilemma.

Thus, the Committee feels that the most promising possibilities of finding time for increased emphasis on fundamental science, engineering science, and humanistic or social studies are (1) elimination of some of the present curricular material and (2) increased effectiveness of instruction. If these criteria for elimination of material of a high vocational or skill content are applied rather forcefully by engineering faculties, it is felt that opportunity will be found within the usual time limits to increase basic studies as indicated in this Report. This will not be achieved, however, by repair of patchwork curricula. It requires complete reconstruction of curricula.

The Committee, after careful consideration, takes no position with regard to the length of the program. It believes, however, that further experimentation is called for in all four of the means suggested for introducing new curricular material.

Evolution of Engineering Curricula

The great changes in physics and chemistry over the past thirty years and the equally great advances in engineering practice do not seem to have produced an equivalent counterpart in a reorganization of engineering curricula. A group of industrial advisors to the Committee has pointed out that the problems in production and manufacturing are now demanding greater and greater scientific background for engineers. As one example, emphasis was placed upon automation as a current problem of the machine designer. The need for such instruction is critical in certain industries, and several of these offer such courses to their personnel. If this is generally true, engineering education may be a decade late in giving emphasis to electronics in the curriculum of mechanical engineering or in teaching applied electronics as a part of machine design.

Unchanging Factors in Curriculum Design

It is relatively easy to look backward and recognize changes; it is more difficult to visualize what lies ahead. After facing many questions regarding the future of engineering practice, one is likely to conclude that the teaching of practice, as it exists today, will always be of limited use because the graduate is certain to find practice changing from year to year. And, as a matter of fact, the engineering art taught in colleges will normally reflect

practice that is already obsolete in part, since the teacher's knowledge of practice becomes rapidly outdated.

But fortunately, some things do not change. Reactions, stresses, and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics, and heat flow will be as important to the next generation of engineers as to the present one. Solids, fluids, and gases will continue to be handled, and their dynamics and chemical behavior will have to be understood. The special properties of materials as dependent upon their internal structure will be even more important to engineers a generation hence than they are today. These studies encompass the solid, unshifting foundation of engineering science upon which the engineering curriculum can be built with assurance and conviction.

Attitudes of Engineering Faculties

The problem that faced the Committee on Evaluation of Engineering Education soon after its organization was to think through the implications of the steadily increasing importance of the engineering sciences upon curriculum design and upon faculty, students, and employer relations. The questions to be answered were of the following nature. Would faculties believe that much stronger emphasis upon the engineering sciences and the basic sciences will produce only research men? Would the employer be pleased with graduates of such programs or would he prefer men able to earn their salary immediately upon graduation without special job training? Could students undertake a more scientific program without excessive failures?

Not knowing the answer to these questions, the Committee suggested in its Preliminary Report the concept of bifurcation as a possible means of transition from the present curricula, which are largely of the general professional category, to the strong scientifically oriented curricula that it visualized as being required for an unknown, but in no sense negligible, percentage of future graduates. As defined in the Preliminary Report, the scientifically oriented curriculum included increased emphasis upon mathematics and physical science, the engineering sciences as previously described, and a two-year sequence of courses in engineering analysis, design, or the study of engineering systems.

The discussions of the Preliminary Report which were forwarded to the Committee by the colleges of engineering established a reasonably clear viewpoint. This conceensus of engineering faculties consisted of three parts: (1) a strong support for higher standards of accreditation for engineering education but not for designation of especially meritorious curricula, (2) a nearly universal institutional reaction that engineering curricula should not be subdivided into two functional stems but a recognition of the usefulness of functional variation at the top, and (3) a growing desire for a deepening and broadening of basic science content throughout all engineering curricula.

Viewpoint of Employers

After receiving this expression of attitudes from the engineering institutions the Committee determined to learn something of the viewpoint of employers. At a meeting in Atlanta, Georgia, in February, 1954, seven of the largest employers of engineers were invited to advise the Committee. These organizations employ all types of engineers in all functions from research to sales and construction. In fact, most of the organizations represented employ only a small fraction of their engineers in research, development, and design. On the average less than twenty-five per cent of their engineers work in these fields. One company has most of its engineers employed in operation and another in manufacturing. A third has one of the largest construction organizations in the country. Several employ nearly one half of their engineers in sales. Nevertheless, the industrial repre-

sentatives who were present concluded that they would prefer nearly all of their engineers to be trained in scientifically oriented curricula.

The industrialists emphasized that their sales, manufacturing, operation, and maintenance engineers need strong scientific backgrounds just as much as do their research and development engineers and their designers. They were unwilling to sacrifice courses in engineering sciences to provide time for the study of technology or administration at the prebaccalaureate level, since they believe that these can be obtained under company sponsorship when needed.

Initially the industrial advisers to the Committee represented only large employers. Therefore, the Committee requested one of the companies to make a survey of a number of smaller organizations at the operating and manufacturing level. The returns indicated no criticism of the technical competence of engineers but raised questions concerning (1) the adequacy of their background in basic science, engineering science, and humanistic fields and (2) concerning their capacity for effective communication. This reaction with regard to the inadequacy of basic science and cultural background was essentially unanimous.

Abilities of Engineering Students

The Committee on Evaluation has also given consideration to the question whether a stronger emphasis upon basic science and engineering science would lead to increased failures in completing engineering curricula. Some who have experimented in this direction give assurance that this common assumption is not necessarily true. The best authority to the effect that engineers can handle additional work in basic science and engineering science without undue difficulty lies in the results of national tests. These indicate that at both the undergraduate and the graduate levels, engineering students show the same high level of mental ability as students of the physical sciences. It seems reasonable to conclude, therefore, that the principal groups of engineering students will prove able to complete whatever type of curriculum the profession of engineering considers necessary preparation for its prospective members.

Opportunity for Scientifically Oriented Curricula

The consideration of curricula cannot proceed wholly on a philosophical or qualitative basis but must eventually be approached quantitatively in semester hours or at least in terms of fractional percentages of the total program. The Committee on Evaluation, in order to clarify for itself the practicability of its suggestion that curricula of the usual type can be designed with an enhanced scientific orientation, has developed for consideration the broad outline of scientifically oriented curricula. *It intends this skeleton curriculum to be considered as suggestive rather than restrictive. The great need of engineering education at this time is for experimentation with, rather than standardization of, curricula.*

In defining an engineering curriculum the Committee on Evaluation has first indicated the need for *mathematics through differential equations;* however, another application of calculus, such as mathematical statistics and probability, might fit more effectively into industrial or sanitary engineering. Nevertheless, for many existing curricula this means at least one additional course in mathematics. The recommendation that *physics should be extended through an introduction to modern physics* will require more than the usual eight semester hours of sophomore physics, even though some time may be saved by elimination of problems involving semi-engineering applications. There is a growing belief that *some acquaintance with organic chemistry and a working knowledge of physical chemistry is essential to all engineers* and that this objective can not be accomplished within the usual course in freshman chemistry. For most curricula these changes in mathe-

matics, physics, and chemistry would probably require a total of at least six semester hours of additional study.

The second major factor in the original definition of scientifically oriented curricula included nine engineering sciences in sufficient strength to justify their separate listing. *These have now been regrouped into six engineering sciences:* (1) mechanics of solids (statics, dynamics, and strength of materials), (2) fluid mechanics, (3) thermodynamics, (4) transfer and rate mechanisms (heat, mass, and momentum transfer), (5) electrical theory (fields, circuits, and electronics), (6) nature and properties of materials (relating particle and aggregate structure to properties). *These titles should be regarded as generic and broadly definitive rather than as representative of courses now being offered.* In regrouping the engineering sciences into six categories, the Committee made no reduction in the minimum time considered appropriate for their study, which represents one quarter of the engineering curriculum.

The third major element in the definition of an engineering curriculum is that it must contain an integrated sequential study. By this is meant that mathematics and the basic science shall be used proficiently in the courses in engineering science and that the latter, in turn, shall be used proficiently in engineering analysis, in the study of engineering systems, and in the preparation for creative design work. For the scientifically oriented approach it seems desirable that analysis, synthesis, and creative design cover four successive semesters at an intensity to be represented by five or six semester hours per semester.

In addition to basic science, engineering science, and engineering analysis and design, allowance may be made for a minimum three-credit-hour humanistic or social science course each semester for at least seven or eight semesters and also for a small amount of required technology. The general outline of any scientifically oriented curriculum may therefore be described in five blocks of courses under the following headings: humanistic and social studies, mathematics and basic sciences, engineering sciences, engineering analysis and design, and electives.

SUMMARY OF TIME DISTRIBUTION FOR SCIENTIFICALLY ORIENTED ENGINEERING CURRICULA

	Proportion of the Curriculum
(1) Humanistic and Social Studies (Pages 39–41)	*About one fifth*
(2) Mathematics and Basic Sciences (about equal weight) (Pages 36–37)	*About one fourth*
(3) Engineering Sciences (Page 37)	*About one fourth*
(4) Sequence of Engineering Analysis, Design, and Engineering Systems, Including the Necessary Technological Background (Pages 37–39)	*About one fourth*
(5) Options or Electives in (a) Humanistic and Social Studies, (b) Basic Science, (c) Engineering Science, (d) Research or Thesis, (e) Engineering Analysis and Design, (f) Management (Page 41)	*About one tenth*

It will be noted that the fractions given do not total exactly one-hundred per cent. Hence, it should be evident that the Committee does not desire this suggested distribution of emphasis to be restrictive. There will be many reasons for variations among institutions and among departments of a single institution. *Experimentation is strongly encouraged.*

In the above table, items (1) through (3) consume about seven tenths of the curriculum. They define an area of common orientation which the Committee regards as essential to a unity of understanding by students in different engineering fields. There is no reason why such unified understanding can not be achieved by somewhat different courses, with dif-

ferent instructors. It will not be achieved, however, if technology is substituted for basic and engineering science or if courses with names from fields of engineering science are presented merely as a necessary sideline to the objective of teaching current practice.

The Committee's interest in the curriculum outline above is centered in: (1) the indication that the concept of four-year curricula with scientific orientation is practical, (2) the indication that considerably more than the usual "common freshman year" is an evolutionary result that could accompany scientific orientation of curricula if desired, (3) the opportunity presented by elective study for meeting the interest orientation of students and the functional needs of engineers engaged in research and design as well as in management and construction.

Special Factors that Influence Undergraduate Educational Achievement

Student Selection and Advanced Standing

It is recommended that high school students interested in engineering be encouraged to prepare themselves adequately for engineering work in high school by developing proficiency in the use of English and mathematics and by gaining an understanding of science, particularly physics and chemistry. A most effective way of so encouraging these students is to make proper adjustment in the work required of them in engineering schools. This may be done by allowing college credit for previous work, or, if this is undesirable, by making the credit hours required for graduation flexible and dependent upon the preparation and skills of the entering student. A student should not be required to repeat work in college if he is adequately prepared by work already covered or by proficiency previously acquired in high school or elsewhere; instead he should be allowed to proceed into more advanced work. When so excused from taking a specific course on the basis of previously developed proficiency, he should not be required to substitute other work not demanded of other students, for this requirement always discourages students from presenting advanced work for entrance. *However, proficiency should be determined by examination and should not be assumed because of the acquisition of high school units beyond those required normally for admission.*

Requirements for admission to an accredited engineering curriculum must of necessity be rather rigorous to insure adequate capability of the student to pursue engineering studies in an orderly and effective manner. The Committee, therefore, recommends the following minimum requirements for admission:

1. Graduation from an accredited secondary school, or demonstration of equivalent education.
2. Demonstrated capacity for satisfactory achievement in engineering.

It should be recognized that the minimum requirements listed above impose great responsibility upon directors of admission for proper selection of students for engineering colleges, especially when the availability of required courses in the various high schools is taken into consideration. Such students should normally accumulate at least three units of English, four of mathematics, and at least one unit of physical science if they are to make satisfactory progress in engineering schools whose curricula are organized on a high professional level. Furthermore, unless suitable screening techniques are applied, such students should stand in the upper quarter of the overall integrated group of high school graduates. It is suggested that pursuit of vocational courses should be discouraged as preparation for engineering and that not more than two of the sixteen units for entrance should be considered from drawing, shop, or other vocational work. Additional background in mathematics, science, and humanistic and

social courses is of far greater benefit to the student.

The Committee also recommends that colleges should:

1. State their requirements for admission clearly.
2. Elect to admit students with deficiencies only when there is strong evidence to indicate probable success in engineering and always state clearly what those deficiencies are and how they may be removed.
3. Maintain records of criteria used to determine admission.
4. Use such records to improve the screening process.

Students transferring from accredited junior colleges, liberal arts colleges, or other engineering colleges should be admitted on a provisional basis; the final transfer of their credits should be delayed until their subsequent records indicate maintenance of the achievement level required for graduation. A realistic evaluation of credits presented for advanced standing should be made on the basis of course content or a proficiency examination rather than on an inflexible basis of equivalent credit hours.

High School-College Articulation

As preparation for engineering education there is no substitute for scholarly levels of instruction in high school with adequate emphasis upon developing both interest and reasonable proficiency in mathematics, English, physics, and chemistry. The Committee on Evaluation believes that a great deal can be done to improve the scholarly quality of education offered in the high schools. This can best be accomplished by developing close working-relationships between engineering colleges, high schools, and ECPD guidance committees at the local level. The ECPD Committee on Guidance should be encouraged to extend its activities in this direction. Some engineering colleges have developed conferences and educational programs, jointly participated in by high school and college teachers. Several industries have provided the financial support for such educational programs. These programs can be highly effective in giving high school teachers an insight into the nature of the scientific and mathematical preparation which is needed by students who plan to study science or engineering in college.

In order to encourage high school-college articulation, it is recommended that a study be undertaken by ASEE in cooperation with professional and industrial groups and societies representing mathematics and the pure sciences for the following purposes:

1. To determine specific techniques for identifying, encouraging, and developing those high school students who have aptitudes for engineering or science.
2. To determine methods for developing adequate study habits and a suitable level of performance in reading ability for those students planning to attend college.
3. To develop specific techniques of reaching high school faculties and administrators in order to enlist their cooperation in a constructive program to improve the quality of high school preparation, particularly in mathematics, physics, chemistry, and English.
4. To determine, at each university engaged in teacher training and having a college of engineering, ways of providing advanced study as a part of high school teacher education that would make such teachers more proficient instructors in the subjects necessary for admission to engineering.
5. To develop specific techniques for presenting these problems and their possible solutions to high school administrators, teachers, and the general public.

Providing Opportunities for Gifted Students

Leading engineering educators have long felt that the standardization of engineering curricula in the United States has provided too little opportunity for outstanding students with creative talents

to develop these capacities at the greatest possible rate. Most courses are organized to proceed at a rate that can be followed by the average and, commonly, by the below-average student. At some place in the undergraduate program there should be an opportunity to break this "lock step" and permit the student full play of his intellectual and creative powers.

The Committee is aware of three possible methods for providing such opportunities. The first is the special curriculum, designed both in content and in method of administration to challenge adequately the exceptional group at the top of a class. The second method is that of permitting the exceptionally able student to elect his program widely with due precautions against excessive specialization; to carry as heavy an academic load as experience indicates he can handle; and, in general, to let him build out of the courses that may be available, including in special cases appropriate graduate courses, a program that stimulates and challenges him. The third method, and the one that philosophically has the greatest appeal, is that of giving the student a great degree of personal freedom to study individually under general supervision and guidance in whatever way appeals to him as being most effective in his individual case. Combined with this, of course, must be a rather infrequent but very searching examination designed to provide an overall measure of his accomplishment and to test his level of understanding in a broader and yet more penetrating way than the usual term examination.

The first and second methods—that is, the special curriculum for a gifted group and the individually elected curriculum, respectively—are in regular practice at various institutions in the country. Any adviser, if he is given freedom to adjust the curriculum, can adopt the second method whenever he recognizes among his students one who is capable of benefiting from such a program. While the results of such procedures are extremely difficult to measure with any degree of certainty, the evidence is not unfavorable.

In the case of the third type of program, however, experience in engineering in this country has not been conspicuously convincing. One difficulty is that, given a large measure of freedom as to place, method, and program of study with only the most general sort of restraint in the form of comprehensive examinations at the end of one- or two-year periods, very few students will absent themselves from rather regular classroom exercises if these are handled in a reasonably interesting and inspiring manner. Class exercises are an exceedingly effective way of acquiring basic, scientific disciplines. Other students who take seriously the admonition to study independently have often found that they lacked the necessary self-discipline to achieve the same intensity of intellectual effort and actual accomplishment as that achieved by the regular students. This has sometimes been revealed disconcertingly when such a student has later been faced with the searching doctoral examination in which demonstrations of relatively elementary ideas, but at a profound level, have been required. The student who has enjoyed complete freedom under general guidance has often failed to acquire the degree of exacting mastery of basic principles that is expected.

The brilliant student who becomes the personal protege of a wise and able professor, however, may attain extraordinary achievement under a free program. This rather rare student is obviously an exception to all rules, and the perceptive and wise faculty member will break many rules in order to allow him to develop his own initiative and ideas. Such students will set their own courses in life, faculty members notwithstanding, and they do not constitute the problem being considered here. The adequate social development of such individuals, however, may be a serious problem. Intellectual development and social development are interrelated; hence, one cannot be accelerated and the other ignored.

It is, therefore, the rather select group found in the top ten per cent of a good class with whom faculties should be more concerned. There are, of course, many ways in which the monotony and tedium of the highly organized classroom course can be relieved for these students. The privilege of joining faculty societies of scholars should provide exhilarating motivation in this direction. Such students should be given individual encouragement that will help stimulate them to something beyond the ordinary performance. In the United States there is a great need for continued experimentation in the search for the solution that apparently is still to be found for this important problem. The European solution, although excellent in its natural setting, has not proved susceptible to direct transplantation to this country. The strongest encouragement should be given to those teachers and administrators who would like to experiment in increasing the responsibility of gifted students for their own education.

Foreign Students

The foreign student brings both assets and problems to an engineering school in a ratio that can be greatly influenced by wise administration. Also, our world obligations place a responsibility upon us to make the foreign student's experience valuable to him in terms of the problems and opportunities he faces when he returns home.

Credentials of foreign universities are often difficult, if not impossible, to evaluate in terms of American standards of admission. Hence, internal placement examinations are sometimes necessary. There are difficulties the foreign student experiences in adjusting himself to the university in terms of language and cultural tradition. Insistence upon reasonable facility in conversational English is, therefore, essential. There may also be serious financial problems.

The foreign student who is well prepared is likely to be well advanced in theory but inexperienced in laboratory procedure. Sound programs for such a student will recognize these facts.

ROTC Credit

The Engineering Colleges recognize their obligations to the nation to train through the mechanism of ROTC a supply of future officers for the Armed Forces. It is believed that this should be accomplished without compromise with the basic educational concept developed in this Report.

The Military Affairs Committee of the ASEE, at the request of the Committee on Evaluation of Engineering Education, made a survey to determine the credit being allowed currently for advanced ROTC courses and what credit was considered reasonable. The replies made it clear that the majority of engineering colleges do not recognize advanced ROTC as an appropriate substitute for engineering courses. However, an average of about six credit hours is being accepted as a substitute for humanistic and social studies. More than fifty per cent of the engineering colleges do not allow credit for advanced ROTC as a substitute for engineering courses, and about twenty-five per cent do not allow credit toward humanistic and social science courses.

The Committee on Evaluation recommends that no credit be allowed for advanced ROTC courses as a substitute for engineering courses. The Committee also looks with apprehension upon appreciable substitution of ROTC credit for humanistic and social studies. Although the context of certain ROTC courses may involve geography and government, fundamental differences exist between these courses and those offered in the humanities and social sciences.

The major differences in course objectives, course organization, and qualification of instructors are valid reasons why the ROTC courses generally cannot contribute in a major way to the professional and liberal education of an engineer as do the other courses in the curricula. Ideally, no substitution of ROTC credit should

be allowed either for engineering courses or for those in the humanities and social studies. *As a practical matter it is urged that substitution of advanced ROTC credit for humanistic and social studies alone should not exceed one quarter of the total credit allotted to this area.* Experiences in a wide range of institutions demonstrate that the advantages to the student of ROTC training are sufficient to attract his enrollment without diluting his professional and cultural education through granting academic credit for ROTC beyond the amount proposed.

Graduate Study in Engineering

The growth of graduate study in engineering in the past two or three decades has been remarkable.[1] Both statistically, and in the minds of those concerned with engineering education, graduate study has become an element of such major importance that it necessitates serious attention in any evaluation of engineering education.

The need for post-baccalaureate study by those who are to advance our highly complex technology is generally recognized. The four-year program, even with increased scientific emphasis, simply cannot provide the depth and breadth of scientific foundation and the background for creative thinking in design which are needed. *The need for graduate education varies with the rate of advance in the use of science characterizing various fields of engineering; it is greatest in those fields in which this rate is most rapid or to which science can contribute most directly.* Industry places a substantial value upon graduate education, as indicated by recruiting efforts, salaries, and advancement to positions of high degrees of responsibility. Furthermore, as is implicit in this Report, engineering education must be based more and more on a profound knowledge of the basic sciences and so will require that an increasing proportion of its teachers will have the benefit of advanced graduate education. It is obvious, therefore, that educational institutions with *adequate* resources to support good graduate work in engineering have not only an opportunity but also an obligation to attract and develop as many well-qualified graduate students as possible. Those educational institutions which operate solely on the undergraduate level have also an obligation to participate by preparing and encouraging their students to take graduate work elsewhere. Many small schools have made impressive records in furthering graduate education in this way. Even institutions having well developed graduate programs should encourage their better students to enroll in other similarly qualified institutions for graduate study because of the educational advantages to the student of new scholastic environments and different personalities among their instructors.

It is traditional for institutions of higher learning to serve two ends: disseminating and extending learning—that is, education and research. It is common to distinguish three separate yet closely related activities: undergraduate education, graduate education, and fundamental research. When these are maintained in adequate balance and properly correlated, each can enormously strengthen the other two. One kind of correlation that is very effective is attained by having faculty members who wish to engage in all three activities.

Objectives of Graduate Study

Although one conception of the purpose of graduate study is that of increased specialization in a narrow field, the Committee feels that a broader conception, developed as discussed below, is more significant. For example, the topics in organic and physical chemistry or in solid-state and nuclear physics, which seem so essential to one "specialized" graduate program in engineering, will be almost

[1] See, for example, "The Growth of Graduate Study in Engineering," by Henry H. Armsby, *Journal of Engineering Education*, Vol. 45, No. 3, 1954, pp. 220–227.

exactly duplicated in many others. Graduate study in engineering thus has a broad common base in science and mathematics. Such concentration as may be desirable, for example on a thesis, should be undertaken with the objective of developing breadth of understanding and capacity to solve difficult problems. Naturally the student who studies intensively in one particular field possesses a ready skill in this special area which may have immediate utility. Such facility, however, has only a temporary value without the overall intellectual growth through which the individual can master new techniques in any of numerous fields. *The acquisition of techniques is, therefore, incidental in graduate educational experience, the deepening of insight and understanding, and the development of the stronger intellectual and scientific foundations that are required for real mastery of the field involved.*

Hence, the objectives of graduate study in engineering are the development of (1) a more general and fundamental understanding, not only of the sciences specifically underlying a particular field, but also of those underlying related fields; (2) more general and more powerful methods of analysis; (3) capacity to read with understanding the advanced work, classic and contemporary, through which the field is advancing; and (4) courage, imagination, and technical capacity to make new advances and to know the methods, as well as the failures and successes, involved in such advances.

A recognized objective which is being implemented at a few institutions is that of continuance of general education outside the fields of engineering and science at a serious and mature level. This is particularly important for those who expect to become engineering teachers. The growing broad responsibilities of all engineers further justify increasing attention to this objective. Culture can, of course, be acquired by penetrating self-study in a variety of fields or assimilated by close association with scholars. Its acquisition is seldom neglected by those who are regarded as leaders in their own fields, nor can it be by those who would live a complete life.

Requirements for a Strong Graduate Program

The essential requirements for a strong graduate program are few, simple to state, but difficult to achieve. They are: (1) a specially qualified faculty, (2) students of superior ability, and (3) adequate administrative and financial support. Without each of these requirements, graduate work worthy of the name is impossible. Given these characteristics, such elements as curriculum, requirements for degrees, laboratory facilities, sustaining research programs, library, student housing, associations with the leading national and international centers in the field, and intercourse with related and underlying fields of learning and research can be expected to evolve. Each of these three requirements is examined in some detail below.

The Graduate Faculty—To an even greater extent than in undergraduate education, an outstanding faculty is the single most important requisite for successful graduate work. As emphasized in the section on the Selection and Development of an Engineering Faculty any good teacher must have drive, enthusiasm, judgment, and a sincere interest in the development of men. Although it is not possible to draw up a set of rigid specifications for a graduate faculty, the following characteristics are among those common to many outstanding graduate teachers in engineering:

1. A creative talent and a receptiveness to new ideas which manifest themselves in the constructive use of new knowledge.
2. A fundamental and critical understanding of one or more fields of engineering.
3. An ability to relate knowledge and experience in one field to a total concept involving many fields of endeavor.
4. A high intellectual capacity and an

insatiable desire to learn and to understand.

5. A profound understanding of the basic sciences, including mathematics, as they relate to engineering.

The full development of the qualities listed above means that the successful graduate faculty member is either actively contributing to the frontiers of knowledge or is engaged in applying new knowledge successfully to the solution of challenging situations. The graduate faculty member should enjoy teaching. He must desire to transmit his evergrowing knowledge and understanding and urge for intellectual growth to young people. In his teaching, however, he should deal with students as colleagues, rather than as pupils, whether in the classroom, office, or laboratory. This obligation to the student cannot be fulfilled properly unless the teacher is doing creative work.

The strong faculty is composed of a group of men of diverse talents and interests who are dedicated to the overall objective of providing the stimulation and environment for the professional growth of themselves and their students. Many members of the faculty teach both undergraduate and graduate students. This is desirable, but the nature of the tasks and attitudes in teaching advanced subjects must necessarily be somewhat different from those in undergraduate teaching.

The graduate faculty deals with a student body comprising a selected group of the best students who have completed an undergraduate course of study and have indicated a keen interest in preparing themselves for high-level professional work. While many such students are interested in research, development, and creative design, the rapid growth of technology is also creating demands for men trained at the graduate level to employ greater understanding in the solution of problems in the area of production, management, etc. There is good evidence that the best graduate education for these differing functions in engineering is one that will develop the intellectual capacity of the individual rather than high specialization toward a given functional objective.

Faculty-Student Relations—Because of the close associations that are typical of graduate work, graduate teachers have an opportunity to know their students well and to provide the individual inspiration and leadership that is an essential part of the graduate environment. Moreover, this relationship properly used insures that the student is impelled to take the initiative and to work on his own or as a full-fledged partner without undue assistance. *Nevertheless, the wise teacher recognizes the great transition involved in movement from undergraduate to graduate study and accepts responsibility for exerting the skillful leadership needed to bring the student quickly to the stage of independent study.*

Though interested in developing student competence and enthusiasm in his own field, the good graduate teacher stimulates student interest in many fields. Such teachers are on the alert to detect evidence of imaginative and creative thought and to give the encouragement and support necessary to bring such ideas to full development.

The Graduate Student—A faculty having the requisite abilities for conducting a graduate program will insist that the graduate student body be intellectually and temperamentally qualified for graduate level work. First-rate graduate work makes substantially greater intellectual demands than undergraduate work. It also demands more in imagination, in self-reliance, and in capacity for independent work under less specific guidance.

Because of the greater dependence of success upon centered interest and intellectual outlook and character, the selection of graduate students must depend upon individual appraisal. Certain general guides are, however, widely used. Not all of those who receive a baccalaureate degree are normally regarded as qualified for graduate work. In general, experience indicates rather marked correlation between a student's standing relative to his

undergraduate classmates and his subsequent performance in graduate work. A very large percentage of the qualified engineering graduate students will have been top-quarter undergraduates in their field, though this rough criterion will vary somewhat with the rigor of the school and with individual student development. The majority of good doctoral prospects will lie within a much narrower fraction, perhaps the top tenth or less, but those students who make top grades by rote learning in an undergraduate program may still be poor prospects as graduate students. *The attitude that most students deserve a chance at graduate study is inimical to the intellectual objectives to be achieved and may be damaging in its effect upon those who are qualified for graduate study as well as those who are not.*

Selection of graduate students is a relatively straightforward process for a faculty having high intellectual standards and the courage of conviction regarding these standards. Good students can be selected, however, only after they apply for graduate study. In order to encourage the best students toward graduate work, the great need is to provide the undergraduate student, preferably at the junior level, with adequate information about graduate opportunities and requirements and also about the advantages or disadvantages of graduate study as a means of attaining professional stature. Our best qualified undergraduate students repeatedly undergo a skilled, persuasive presentation of the opportunities available to them in immediate employment. They should have an equal opportunity to know and to examine carefully the available alternatives.

Stipends for graduate students should be increased to a level more competitive with advancing engineering salaries and should reflect the fact that present-day graduate students often have dependents. Employers of engineers must understand that they have a very great stake in increasing the number of graduate students, even though they may lose in the number of immediate employees, and even at the cost of competitive graduate or research fellowships that only they can provide.

Administrative and Financial Support—No graduate school can be successful without the full support of the administrative officers. To be able to provide such support, the administration must have full knowledge of the special problems created by the existence of a graduate school. As at the undergraduate level, the administration has the responsibility to build a strong faculty, to encourage the attraction and selection of qualified students, to provide adequate facilities, and to create a favorable intellectual climate.

The job of building a strong graduate faculty composed of men with the necessary attributes and competencies is difficult, never ending, but not impossible. *A competitive salary scale for a graduate faculty is imperative. Creative talent is always in greater demand than supply. In addition, proper facilities must be provided and a favorable environment developed so that men may pursue those activities of research, development, and creative design which mark the life of the graduate school teacher.* Such facilities include laboratories, adequately equipped; the various service facilities; and an adequate library. Facilities for students, including desks and laboratory space, and housing where necessary, must be provided.

Last and perhaps most difficult of all, the administration must itself have the spirit of dedication to the advancement of knowledge without which no graduate school can become really great. Such a spirit is reflected in an ability to recognize:

1. That in evaluating teaching loads account must be taken of the greater time required for preparation of graduate subjects. Graduate courses should be under constant change with new knowledge being fed in as soon as it becomes available.

2. That research, development, and creative design, which demand a major portion of the professor's time, are part and parcel of the graduate teaching job.

3. That the supervision of thesis research is time consuming even though it is also a rewarding educational duty.

4. That the best graduate programs are based upon the strength of particular faculty members rather than upon any fixed curriculum content.

5. That a strong graduate engineering program requires equally strong independent programs in the basic sciences.

To meet the above responsibilities involves an annual cost per student from two to ten times as great as that required to educate an undergraduate. No school of engineering should consider instituting a graduate program unless it is willing and able to provide the additional funds required.

Policies that permit full opportunity for the professional growth of individual faculty members must be such as to meet the special problems that arise in connection with sponsored research projects, consultation for industry and government, and participation in community affairs. These activities in proper balance provide opportunity for continuing development of the faculty.

In the last decade the amount of sponsored research carried on by engineering colleges has grown enormously. Sponsored research programs properly conceived and carried out can be great assets to both graduate and undergraduate schools. They provide a means of professional development for staff members. However, only when tied closely into the graduate school program will they provide opportunity for graduate students to deal with real and challenging problems as a part of their education. A criterion of acceptability for each project is that competent faculty members actively desire to work on it. However, growth in the size of the projects may so consume the time and energies of the staff that their contribution to education diminishes, particularly if the work becomes more routine and less challenging.

The administration is responsible for the establishment and control of such programs, for retaining proper balance between the sponsored research commitments and the other parts of the educational program of the institution, and for taking whatever steps are necessary to insure that services performed on projects provide opportunity for professional growth for the faculty and the graduate students.

General Character of Graduate Programs

Though graduate study in engineering may appear to be but an extension of academic preparation for the more scientific phases of engineering practice, it should represent a considerable advance beyond undergraduate study in attitudes as well as in subject matter. Undergraduate education, even when developed on sound scientific principles, must be based on simplified concepts if it is to be understood by undergraduates and if it is to serve as an introduction to practical engineering design. The more advanced concepts are, of necessity, intelligible only on a considerably higher mathematical level, and yet it is these advanced concepts that form the basis of our most penetrating knowledge of physical phenomena.

Comparison with Undergraduate and Specialized Programs—The creation of new products, industries, structures, or operations will involve not only scientific analysis of a higher order, but also new concepts of synthesis or design. Training in these categories is limited in undergraduate curricula, not only because students must master a minimum amount of knowledge before they are prepared to extend or apply it, but also because individual instruction on this level is too costly in view of the number of students involved.

Furthermore, genius is not well nurtured by the fixed curricula so characteristically prevalent today in undergraduate fields. *Hence, graduate study should be flexible and custom tailored to suit the individual.* This does not involve unrestricted selection of electives, for universities take seriously their responsibilities in awarding graduate degrees and rightly approve only those subjects that contribute substantially to the major and minor

fields. In engineering one of the required studies is almost invariably advanced mathematics, for the graduate student requires additional mathematics to conduct advanced work and to convey his scientific explanations to others. *On the level of the master's degree anything less than a full-year course in mathematics beyond elementary differential equations appears to be inadequate for effective understanding and use of the scientific principles on which advanced work in engineering will almost inevitably be based.* The doctoral level demands at least an additional year of mathematics. As stated previously, few engineering courses are taught in a manner to make significant contributions to the student's knowledge of mathematics, nor is time available for this purpose.

Student Initiative and Responsibility—Initiative and willingness to accept responsibility become most evident when graduate students undertake the research for master's theses, but more especially for the doctoral dissertations. Such labors usually require (1) an intimate knowledge of related scientific and mathematical principles, (2) experience in collecting relevant and discarding irrelevant information from many sources, (3) the imagination and ability to devise a new and logical method of attack, (4) the perseverance to complete the analysis, (5) the planning and performance of experiments to check the analysis, (6) the willingness to digest these results, and (7) the exercise of judgment in drawing valid conclusions. An appropriate thesis offers exceptional opportunity for additional educational experience and development of the student as well as a test of the degree of their achievement.

Importance of Science—A comprehensive knowledge of mathematics *alone* has little practical utility for an engineer unless it is employed to effect an equally profound understanding of those physical, biological, or engineering sciences which are the necessary background for creative design. All engineers must deal with materials, and they need to understand the behavior of materials when subjected to varying service conditions in mechanical, electrical, chemical, or nuclear fields. Recent advances in solid-state physics indicate that knowledge of materials on an atomic and a microscopic level is required for an understanding of macroscopic or phenomenological behavior. Advanced training in science is thus most important for the graduate engineering student. It matters little whether this science is offered in special courses or integrated into others. It must be covered and can appropriately grow into the proportions of a full-fledged minor, or become an integrated portion of the major field.

Nature and Importance of Research—A young engineer who has an interest in research or development will find his progress more rapid in his chosen field if he can avail himself of the opportunity for the training in research which exists in any good university. The importance of this aspect of graduate study hinges on the exhilarating experience of penetrating deeply enough into some unexplored problem to uncover new truths, and to do this in association with one who has already proven himself a master of the field. The inspiration so derived is essential for a beginner in research, for he must not only learn to circumvent failures but gain the confidence to tackle new and difficult problems as they arise in engineering practice.

Graduate Housing

In graduate even more than in undergraduate work there are important intangible benefits of association with other students and faculty provided by congenial group living in university graduate housing. The graduate student, much more than the undergraduate student, works in an atmosphere of independent individual study and needs for his best growth and development continuous interchange of ideas with and stimulation from students of equivalent intellectual level. *Perhaps no other experience is so likely to develop the inner desire to be truly literate and alive in fields far removed from one's own*

speciality as is a period of congenial residential association with other graduate students. For married students the housing problem takes on a somewhat different form, but the essential issues remain unchanged. Administrative effort to provide housing should be just as vigorous for graduate as for undergraduate students.

Service Programs for Industry and Government

Though it is generally agreed that graduate study in engineering has become indispensable to prepare men properly so that they may contribute effectively at advanced professional levels, only about one eighth of engineering graduates actually acquire graduate degrees. Industry and government have recognized this paradoxical situation and have attempted to find a partial solution through more extensive fellowship programs and more effective industry-university relationships.

In large metropolitian centers late afternoon and evening programs have been initiated by local graduate schools in order to provide opportunity for part-time graduate study. More recently, where travel conditions appear to be unduly discouraging, off-campus graduate programs have been organized. Both represent a service to engineering education when they are carried on as high-level programs, but they give a false sense of achievement if they are not so conducted.

Part-Time Programs

Engineers who are confronted with difficult engineering problems soon appreciate the need for more extensive understanding of fundamental science and engineering science. Their undergraduate studies seldom permitted the extensive preparation in mathematics and physics required for real mastery of basic principles and their application to advanced engineering design or research.

Most frequently, part-time graduate programs are arranged to permit students to attend graduate classes after normal working hours. This arrangement places a heavy burden upon the graduate student. More important, however, is the requirement of a first-class faculty for these evening courses in order to merit the efforts of both institution and student. It is entirely inadmissible to entrust such graduate classes to untried teachers or to men without adequate educational experience. A strong background of practical experience is not sufficient justification for employing an individual as a graduate teacher either on a full-time or part-time basis. Since his appointment as a part-time teacher precludes close contact with other teachers in an academic atmosphere, previous teaching and research experience are essential.

If the course offerings are highly specialized so as to furnish graduate background in narrow fields, outside experts might serve adequately or after some experience even in a distinguished manner as teachers. *However, if the course offerings tend to crystallize into a degree program, members of the full-time faculty must be available to teach at least the majority of the graduate courses.* It is particularly important for degree programs to operate with admission criteria identical with those practiced in the full-time graduate school and to maintain the same standards of performance. Injudicious mixing of auditors or poorly qualified students with candidates for graduate credit is strong evidence that the standards of the program are not at a master's degree level.

The full-time graduate student in a strong engineering school obviously has the advantage of informal association with outstanding faculty members. The evening student may have partial compensation through professional associations in his work. He is usually more mature, but in carrying two jobs he is commonly overworked. As a minimum standard he must have the opportunity, at least in the basic courses, to study under the leading faculty members in his field in order to receive adequate educational stimulation.

It is unnecessary to reiterate what has been emphasized elsewhere many times; the value of a degree is determined by the quality of the faculty that administers it. *A program of appropriate courses alone does not establish a strong graduate school; it must be supplemented by supervised advanced design or research conducted as a continuing program by a distinguished graduate faculty.*

Critical understanding of the basic principles is most impressively demonstrated in a graduate thesis or in equivalent projects of major significance. Without such a creative contribution, whether it be creative design, original development, or research, the graduate degree has deteriorated to a certificate of limited scholastic attainment.

Although doctoral dissertations are now restricted generally to work performed in residence, nevertheless a considerable number of such theses have been completed *in absentia*. There is a widely held conviction within established graduate schools that the major doctoral degree should be awarded only for graduate work in residence that meets high academic standards.

Off-Campus Programs

All that has been said about possible shortcomings of indiscriminate part-time graduate course offerings is even more true of off-campus graduate programs. They are usually organized to meet the educational needs of a particular industry, group of industries, or a governmental research laboratory located an appreciable distance away from the nearest graduate engineering school. Often in their first conception they are not programs leading to degrees.

Unfortunately, more and more the demand has arisen to convert these off-campus programs into advanced-degree programs, in some cases allowing substitution of course work for the graduate thesis. *Real danger to the whole concept of graduate study can come from easy compromise both with respect to the quality of the faculty teaching such programs as well as to the facilities available and the quality of students admitted.* The feeling of obligation can be overpowering, yet the undertaking of responsibilities with inadequate faculty, library, and other facilities can lead only to grave criticism by the professional community and even by the students themselves. The near impossibility of maintaining the high standards expected of resident study without the extensive facilities on the campus has often been overlooked.

One necessary requirement must be the complete educational control of each program by the institution organizing it. Without prior experience in resident graduate study programs a faculty has more difficulty in appraising off-campus activities and should not undertake them.

The Committee feels that many off-campus graduate programs that have been in operation should not qualify for academic degree credit. The Committee also does not believe that any Master's or Ph.D. degree should be given on the basis of an appreciable amount of credit earned in off-campus work. It is possible that certificates or professional degrees may form appropriate acknowledgements of such achievement.

Conclusion

The Committee has been concerned with what it believes to be reasonable, attainable objectives, rather than with Utopian goals on the one hand or minimum standards for accreditation of undergraduate curricula on the other. Nevertheless, responses to the Preliminary and Interim Reports evidenced a wide desire to raise hitherto-accepted minimum standards, and it is anticipated that this Report will assist the Engineers' Council for Professional Development (ECPD) in attaining such a goal.

In closing this Report the Committee wishes to re-emphasize that it believes the spirit of its recommendation in advocating scientifically oriented undergraduate curricula must receive more attention than mere observation of proposed fractions

of time devoted to particular areas. It gave a great deal of thought to the possibility of prescribing the level of attainment in each of the areas of importance in engineering education, but it was unable, except possibly in mathematics, to make a quantitative specification which would take into account the inherently dynamic nature of the basic sciences and more especially that of the enginering sciences. College faculties must perform this work year by year.

The task initially undertaken by this Committee is not finished nor can it ever be finished. The problem of the Evaluation of Engineering Education should always be in the consciousness of the members of faculties of engineering colleges. Each teacher must consider this task a vital personal one and approach it with intellectual vigor and full consideration for the needs of an expanding economy, requiring engineers with vision, creative ability, and sound training of truly fundamental nature. Since these desired qualities cannot be achieved for all students in an identical manner, elective study is recommended. *The choice of electives at the undergraduate level contributes to the development of a stronger humanistic and social background for some engineers and a stronger scientific background for others with a resultant overall strengthening of the profession of engineering.*

The interest and effort shown by the Institutional Committees make this Committee optimistic that improvement will be sought, and it therefore recommends the implementation of its Report at the local level. Improvement of engineering education is the responsibility of every teacher of engineering students.

Appendix A

Historical Background of Previous Evaluation Studies

Since the organization of the Society for the Promotion of Engineering Education in 1893 there have been many studies of engineering curricula which reviewed content of the several programs and gave a distribution of time to the major divisions of the work. Out of the study begun as the Mann Report, published as Carnegie Bulletin No. 11, came the Wickenden Report of 1923–29. It was followed by "Aims and Scope of Engineering Curricula" in 1940 and "Engineering Education After the War" in 1944, produced under the chairmanship of H. P. Hammond. D. C. Jackson's "Present Status and Trends of Engineering Education in the United States" was published in 1939, and its study of curricula may be considered as a supplement to the Wickenden Report.

Since the Wickenden Report is so basic and fundamental it may be desirable to quote a few sentences:

> "The multiplication of trunk and branch curricula based on technical specialization has gone fully as far as can be justified. Further differentiation in courses for undergraduates is much more likely to proceed on functional lines."

> "The most serious deficiency in engineering education is not so much in matter taught or matter omitted in college as in allowing the orderly process of education to stop, where it so often does, at graduation."

The 1940 and 1944 Reports, referred to above, emphasized the division of each curriculum into two major areas, titled the scientific-technological stem and the humanistic-social stem. These two studies renewed interest in the "general academic subjects" listed in The Wickenden Report. The wording used in describing the humanistic social stem is practically identical in both Reports and the time suggested for this area was twenty per cent of the total. This cultural program was to be an integrated sequence running through four years. During the last decade much thought and much study have been given to this phase of engineering education.

Both Hammond Reports recommended the four-year undergraduate program as the desirable norm. However, it was recognized that engineering graduates enter into many kinds of activity and that there should be comparable differentiation in

their educational programs. In summarizing the 1944 Report, Dean H. P. Hammond outlined the needed preparation for widely varying engineering activities as follows:

"In order to provide for the satisfaction of the needs incident to these trends, the (1944) Committee suggests, for consideration, a plan of curricula differentiation in the fourth year, through which three options would be offered within each major professional curriculum: (1) Continuation of the present type of four-year program essentially as a terminal curriculum but with modifications advocated by the Committee, for a majority of students. (2) An alternative fourth year emphasizing subjects dealing with the management of construction and production enterprises. (3) A fourth year intended to prepare for additional years of advanced study by strengthening the student's command and extending his knowledge of basic sciences and mathematics, and by introducing him to the methods of advanced study. This fourth year, and the year or years of graduate study to follow, would be planned as a unit rather than as two stages marked by the usual differences of undergraduate and postgraduate programs."

In 1950–52 the Society conducted a comprehensive study on methods of improving engineering instruction. This study resulted in publication of an ASEE Monograph entitled "Improvement of Engineering Teaching." This report dealt at considerable length with the problem of "how to prepare students to meet new situations with skill, resourcefulness, and leadership." It also treated the collateral problems of "how to instill in the student the desire to continue to learn after graduation and how to provide a cultural foundation which will encourage him to contribute to his local community and to civic groups as a mature, thinking human individual."

The principles of learning outlined in this report stressed "the importance of effective participation on the part of the learner; his motivation through the formulation of a goal; the clear definition of task assignments (preferably defined by the student himself); the evaluation of his progress; and his repeated practice in application." This project was participated in by committees in over 100 engineering colleges of the country.

In 1945 the Division of Graduate Studies of ASEE prepared a "Manual of Graduate Study in Engineering." This was completely rewritten in 1952, and reissued in monograph form. This Manual deals with the following: (1) the objectives of graduate study, (2) organization, (3) transitional studies, (4) developing a graduate faculty, (5) admission requirements, (6) degree requirements, (7) major, minor, and research, (8) the thesis, (9) language requirements, (10) mathematics, (11) examinations, (12) undergraduate courses, (13) non-technical studies, (14) evening classes, (15) cooperative programs, (16) sponsored research, (17) industry institutes, (18) foreign students, (19) student guidance, and (20) teaching loads.

The Committee on Evaluation of Engineering Education gladly acknowledges its debt to the many preceding committees that have reported on their studies of engineering education. Its work bears a close relationship to that of the committees that prepared the "Manual of Graduate Study in Engineering" and the report on "Improvement of Teaching in Engineering" because of the partial overlapping of the committee membership.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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Report of the Committee on Ethics*

Engineers are often accused of being material minded. People say that we decline to take an interest in anything except steel, concrete, water, oil or steam, and that most of us not only refuse to pay any attention to intangibles and abstractions, but that we are mentally unable to comprehend them.

This accusation is not warranted if the concern of engineers and engineering educators about ethics means anything. Indeed, engineers' interest in ethics seems to be quite spontaneous, so that the Committee on Ethics can claim little credit for it. The concern of engineers is altogether gratifying because to create interest in ethics, and to maintain such interest, has been the principal function of the Committee from the day, in 1952, when President Woolrich created it.

One evidence of interest is the volume of correspondence. The Committee on Ethics, like any committee of the Society, is ambitious; it has designs, projects, aspirations. The members are eager to get on with their principal business. However, they have been so tied up by a mass of correspondence that there has been little time to do anything else.

Of course, if maintaining interest in ethics is the Committee's primary aim, the correspondence is all to the good. In any case, correspondence is one means whereby the Committee can serve the members of the Society, as a committee should.

It would be inappropriate, and doubtless impossible, to recite in detail a sequence of evidence to prove that engineers are interested in ethics, and that intangibles and abstractions are not always beyond their comprehension. One example will suffice. An article entitled "Employers, Ethics and Novice Engineers" appeared in the January, 1955, issue of the JOURNAL OF ENGINEERING EDUCATION. The article was reproduced, slightly abridged, in both *Civil Engineering* and *Electrical Engineering*, published respectively by the American Society of Civil Engineers and the American Institute of Electrical Engineers. When these journals were issued, engineers in great number wrote in to express a variety of viewpoints from widely scattered areas, including Australia. The editor of *Civil Engineering* wrote about a survey which disclosed that this article surpassed all other items in that issue in reader interest. The article was reproduced in full or abstracted in many local and special technical and engineering periodicals.

Persons and agencies, both within and without ASEE, have repeatedly urged the Committee on Ethics to ascertain what engineering faculties are actually doing about imparting ethical ideals to their students. During the present school year the Committee passed the question on to the deans of the colleges and schools of engineering. The Committee inquired of the deans in the 149 institutional members of ASEE. 87 replied. That is nearly 60%, and without getting statistical, it surely means that the deans are concerned about ethics.

Not a few of the deans have misgivings about the formal teaching of ethics: "We accomplish more by the good example of our faculties, and an atmosphere of honor and integrity in the college of engineering and on the campus." Ethical deportment of the faculty and a favorable environment on the campus are both obviously essential, regardless of whether or not courses in ethics are offered.

* Presented for the committee by W. W. Burton, Minnesota Mining and Manufacturing Co., June 20, 1955, at the annual meeting of ASEE, Penn State University.

Tabulated data are tiresome but the following tell something of what the colleges are doing:

In a large number of the institutions the dean or other official gives lectures or holds conferences on general or engineering ethics, or both. These institutions constitute 45% of those who replied. The content of the lectures or conferences is apparently well organized. But the operation of the program seems rather casual in some cases. It is not always clear if attending the lectures is a required exercise or whether they are merely available to all students. Some of the faculties probably feel that the real value of the lectures lies not so much in their subject matter but rather in that they help to maintain an atmosphere of honor and integrity in the school.

In some of the institutions it is the policy to depend entirely upon an environment or a spirit of honor on the campus, and on the inspiration and superior deportment of the faculty. These institutions are 23% of those who replied.

In a smaller number of institutions, responsibility for instruction in ethics is assumed by degree departments of civil engineering, mechanical engineering and the like. These institutions comprise 16% of those who replied. Instruction is offered by one or the other member of such departments of instruction, who is enthusiastic and informed in general or engineering ethics, or in both. The lectures are regularly scheduled but usually it was not explained whether students do or don't have to attend. In some of these institutions, courses in ethics are offered by all departments, but more frequently only in one or several. Even when ethics instruction is offered in all departments, the project still remains a departmental undertaking and not a project of the college or school as such.

In a very few institutions all students must complete courses in ethics, and in two or three colleges, courses in both ethics and religion are a degree requirement. Those faculties which require courses in religion contend that religious instruction is excellent for teaching students the difference between right and wrong. Institutions which offer required courses in ethics, in religion or in both constitute 9% of the total which replied.

Finally, there are six institutions whose deans confessed that they do nothing whatever about instruction in ethics. This does not mean that they are not concerned. It doubtless means rather that they are perplexed, and don't know how to proceed. The problems of education in ethics are difficult, and solutions are more so. In fact, one dean has taken the pains to prepare a thought-provoking statement on the professional status of engineers, and with appropriate reference to engineering ethics. He wrote the monograph to clarify his own thinking before he approaches the matter of instruction in ethics.

Members of the Committee have been diligent in their principal business, for the time being, of promoting interest in ethics. Collectively, the members of the Committee have delivered addresses on ethics, or on the subject of professional status with reference to ethics, as follows: Before two meetings of sections of ASEE, before one annual meeting of a national society, before one regional meeting of a Founder Society, before three meetings of state engineering societies, before two meetings of city engineering societies, and before three student branches of national engineering societies. One member of the Committee has even become so distinguished an authority on ethics that he has been invited to discuss the subject before a church group. Members of the Committee have contributed to engineering and technical journals.

Early in the year the Executive Committee of ASEE proposed to the Committee that copies of the (our) Canons of Ethics of ECPD be issued to the deans of the colleges of engineering, and that they be framed and placed in central locations where a majority of the engineering students frequently gather or pass.

The officers of the National Society of

Professional Engineers generously offered to provide and mail the copies, after the Committee had corresponded with the deans and explained what the Executive Committee had in mind. Many of the deans wrote for additional copies. Others reported that they had long since framed and displayed the Canons. In general, the reaction was favorable.

However, the chairman of the Committee has in his possession a photograph which was taken and sent to him by one of the members of the Committee who regularly visits a number of the colleges of engineering. The photograph shows the official bulletin board in one of our well known institutions. Hanging precariously by one thumb tack, among miscellaneous dilapidated documents, is a badly rumpled copy of the Canons. The Committee suspects that the Canons did not get even as far as the bulletin board in one or the other college of engineering.

The Committee on Ethics wishes to express to the officers, the Council and to members of the Society their deep gratitude for consistent encouragement and assistance, and for making the Committee feel, in many ways, that the Society considers its work to be worth while.

THE COMMITTEE ON ETHICS

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ANNUAL MEETING

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Iowa State College

Ames, Iowa

What Is the Responsibility of the University in Contacting the High Schools?*

By J. F. DOWNIE SMITH

Dean and Director of Engineering, Iowa State College

Introduction

The subject of my talk is to be "What is the Responsibility of the University in Contacting the High Schools?" For obvious reasons I am limiting my discussion to the Responsibility of the Engineering Colleges.

Before outlining what I consider these responsibilities, it seems appropriate to outline some of the problems which jointly confront both Colleges and High Schools, and then discuss what the Colleges may do. We must understand the situation before we make recommendations.

The Primary Problem

For a long time, engineering colleges and high schools have been rapidly separating in viewpoint, and there has been an increasing tendency on the part of engineering educators to criticize the activities in high school, sometimes quite bitterly. The most vociferous critics of high school training, however, have perhaps been outside the field of engineering. Some claim that the high school graduate is not properly prepared to undertake study at the college level. His English is poor, and he has not been trained to think.

In a nutshell our primary problem is this: Engineering is becoming highly technical, and in the development of this science there has been increasing dependency upon the use of mathematics, physics, and chemistry. Thus, engineers would like those subjects, and English, taught well in the high schools and they have raised the question whether the high schools are doing this. Many of the high schools are, but these high schools are ordinarily located in the large centers of population—and by large, you understand I am speaking of Iowa, where any town larger than 15,000 is a fair size. But many of the schools are not teaching even enough mathematics to satisfy the engineering educator. The reasons behind this are equally obvious. We, as engineering educators, realize the difficulties of getting budgets to teach all the various courses which our faculty would like to have taught, and at times I am appalled at the number of courses taught in college. For example, on the campus of our college, which is perhaps a typical medium-size land-grant college, with only five divisions, we teach more than 2000 separate courses. The elimination of many of them is not easy, even though some classes have few students.

The high school principal and superintendent are confronted with a different problem. Let me illustrate that again by a reference to Iowa. Of the 836 high schools in the State, 486 have fewer than 50 pupils. In addition, a large part of the rest of the schools in the state have fewer than 100 pupils total, or about 12 male seniors; and thus, from perhaps 80% of the schools we would normally expect fewer than one student coming to engineering college. Under the circumstances the school officials will pay little attention to what the engineering college wants. This is important if we are considering the selection and guidance of high school students. The high school principal says

* Presented at the Annual Meeting of ASEE, Penn State University, June 23, 1955.

that about one-third of his graduating students, on the average, would go to college. The other two-thirds would consider high school their terminal program, and the schools have to consider their average student in preference to those going to college. There might be a serious question, from the standpoint of civilization, whether this should be true. Perhaps the brilliant student should be given much more consideration in high school than he is now given, but from the economic standpoint it would not be easy. In certain of the other countries of the world the brilliant student is given preferred treatment.

Where Do Our Students Come From?

A few years ago one of our staff members made a study of the entering freshmen at Iowa State College, and obtained the following data.

In the year 1951, 38% of the freshmen from Iowa entering Iowa State College in engineering came from high schools with 40 or less in the graduating class. Sixty per cent came from high schools with less than 80 in the graduating class. About 61% came from communities with populations of less than 10,000. Again in 1951, 193 communities and 216 different schools were represented by the 419 Iowa students taking freshman engineering in Iowa State College. *One hundred and thirty-four Iowa high schools were represented by only one student.*

The Changing Emphasis in High School Training

Why has there been any change in viewpoint in the high schools? The situation becomes quite clear when we read what Dael Wolfle has to say.*

Educational Improvements

"In 1870 two-thirds of all high school graduates later earned college degrees. The role of the high school was then clear and unambiguous: it prepared students for college. That is still an important function, but now a minority one. With the great expansion of secondary education high schools have taken on increasingly diversified responsibilities. Not only do they prepare students for college, they prepare them for jobs in offices, for work as skilled tradesmen, for citizenship in an increasingly complex society, and for a variety of other objectives. The declining importance of college preparation is indicated by the decline from 1870 when two-thirds of all high school graduates became college graduates to 1940 when only one-sixth became college graduates. The percentage has increased slightly since 1940, but the college-bound student is still in the minority in most high schools.

"High schools face the double problem of preparing one-third of their graduates for college entrance and two-thirds for the career and citizenship responsibilities of noncollege adults. In this situation different educational theorists have emphasized different values. The college preparatory curriculum has been defended by some while others have attacked it as an anachronistic heritage of an earlier day. 'Life adjustment education' has been hailed as the highest goal of the high school, and condemned as dangerous anti-intellectualism. All these attitudes are one-sided; the choice is not between serving the needs of one group or the other. Both must be served. The two-thirds not headed for college deserve the best the high schools can give them. The one-third who do go to college are also an important group, deserving the best possible preparation for the higher education which they will receive later."

The Teaching of Science Subjects

The effect of this changing emphasis is reflected in matters of interest to us, particularly in the teaching of science subjects.

Members of the Iowa Academy of Science have been making studies of science teaching in high schools of the State, and

* "America's Resources of Specialized Talent," Dael Wolfle. Harper, pp. 252–253.

results of these studies seem to indicate that there is room for improvement. In this study it was found that 79% of the teachers taught some other subject in addition to science, and that some taught as many as four other fields; 48% were teaching in at least three fields, including science, and it is possible that the main interests of those teachers was not in science, but was in other areas.

In 1949, in the last four years of high school about 25% of the students were taking general science; 0.1% earth science; 19% biology; 1.2% physiology; 3.6% chemistry; and 8.4% physics.

(Nationally in 1949, the percentage of high school students taking algebra was 26.8; general science 20.8; biology 18.4; general mathematics 13.1; geometry 12.8; chemistry 78.6; trigonometry 2.0; physics 5.4; physiology 1.0.)

The decrease in enrollment in high school physics, according to the Iowa study, is disconcerting, because there is nothing to indicate that another science is replacing it, as has been the case with physiology and earth science. The effect of size of school is clear. In the high schools in Iowa, 1951–1954, one semester or more of chemistry was offered in 39% of the schools. The percentage increased from zero in high schools with twenty-five pupils to more than 90% in high schools with two hundred or more students.

While high school enrollments are increasing, the proportion of college graduates who are qualified to teach mathematics and science in high school is decreasing. The National Science Foundation indicates * that between 1950 and 1954 the total number of college graduates meeting certification requirements to teach in high school dropped 42% and the number qualified to teach mathematics and science dropped 51% and 56% respectively. Of this number, many find employment in other fields. A recent study showed that only 40% of the 1953 college graduates qualified to teach science and mathematics *were* teaching in November of that year.

The same study indicated that of the high school students who graduated in the upper quarter of their classes, about 40% failed to continue formal education and another 13% dropped out before completing college.

The Teaching of Other Subjects

According to John Francis Latimer, George Washington University, "the number of secondary students studying languages has dropped from three out of four in 1900 to one out of four today. French has dropped from 8% to 5%; German, from 14% to 1%; and Latin, from 50% to 7%. In 1900, at least four out of five students took mathematics; today fewer than half the students do, and of these 13% are taking general mathematics. The biggest slump is in algebra, which is down from 56% to 20%. Physics has also suffered. In 1900, four out of every twenty students took physics. Today it is one of twenty.

"In place of these traditional courses there have been substituted group action subjects, which require little individual effort, and certainly not much demand on a serious intellect."

There have been serious criticisms of the quality of instruction in such fields as English.*

On the other hand, according to Gwillem A. Price, "at the turn of the century, almost 11% of our population could not read or write. The average person did not finish grade school. Today illiteracy has virtually disappeared, and approximately 50% of our boys and girls graduate from high school. More youngsters now get college degrees than finished high school in 1900."

The professional educators do not agree with some of the criticisms. They will all admit that the *number* of subjects taught in the physical sciences has been reduced, but insist that, of those which are actually

* 4th Annual Report, for the year ending June 30, 1954.

* *Time*, January 24, 1955.

taught, the students are as well prepared as they were twenty years ago.

According to Dr. John W. Studebaker,** formerly United States Commissioner of Education, public schools are doing a bigger and better job of teaching the fundamentals of learning today than they did in the "good old days." His conclusion is based upon actual cases in reading, writing, spelling and arithmetic.

In talking this over with representatives from the Teacher's Colleges I find they are quite strong in the belief that the students are better prepared now, and are sure they can back this up with statistics. It is always difficult to give a test which really means the same to one group as it means to another group twenty years later, since the viewpoint of the entire civilization may have changed. Nevertheless, tests which were given to certain students twenty years ago were given to the same grade twenty years later and the newer students got better grades than the previous students.

Part of the criticism of the schools is really not justified. Some of the blame belongs in the home. There has been an increasing failure of the parents to develop character building and training of the mind. This has been delegated in increasing amounts to the school.

Financial Problems

All of the disciplines which we in engineering would consider desirable are not being taught in high school. To some extent, the problem is financial. In many of the states, certainly in the Midwest, the schools are small and the cost of instruction high. For example, in Iowa the present pupil cost in the various districts varies from $200 to $1300. The assessed valuations vary from $1000 to $100,000 per pupil. There are 4400 school districts in the state, but 1200 of them maintain no schools.

There has been a strong move toward reorganization and consolidation, but you realize that local pride—sometimes pride in a basketball team—occasionally prohibits consolidation of schools. Nevertheless, considerable progress has been made.

In many of the rural communities the cost of operating schools is prohibitively high, and the relative cost of training in school and college is sometimes not clearly understood. For example, in Iowa, the state and local expenditures for education are substantially above the levels in most other states in relation to income; yet, seven-eighths of the cost are for elementary and secondary schools, caused partly by the low population density in non-urban areas. The reorganization of the school system is being considered, to see if more efficient operation might be obtained. This is a very important item to the colleges, as well as to the high schools, since, in publicly supported institutions, the high school and the college are *competing for the same money.* There is a limit beyond which taxes cannot be raised without great difficulty. Thus it is mandatory, for the good of the colleges as well as the high schools, that the two get together to improve efficiency in both. There are several obvious ways in which this can be done, but they would vary from state to state.

The time has come when we must encourage and work with the high schools, and not keep lambasting them for the poor job they are doing.

What Should We Do?

I have discussed at some length a few of the problems confronting the high school administrator, for they all have a bearing on our own responsibilities, and affect our judgment in selection and guidance. In order to remedy part of our difficulties we must interest intelligent people becoming teachers in high school and grade school. This cannot be done in adequate numbers under the present circumstances. The salaries paid high school and grade school teachers are woe-

** "101 Questions About Public Education." Nat'l Conference of Parents and Teachers.

fully inadequate, but there is much more to it than that. The prestige of the profession is low. In many countries the high school teacher is looked upon as one of the outstanding professional men in the community. Outside of the athletic staffs I doubt if that is the case in this country. There has been a growing awakening of the public towards this problem, and steps are being taken in many communities towards its solution. This must be done. Because of the financial imposition, many of the talented people who might be interested in teaching in high school have not been attracted to it, and some of those who were at first attracted have since left that profession. To a large extent, the difficulty is traceable to the lack of inducement of people who have the required qualifications to go into high school. People with those qualifications are also in demand by industry, and industry can afford to pay better than high schools.

Unless we can encourage the proper people to teach in high schools, we shall not get from those schools adequately trained students.

High schools are lacking in competent teachers in the sciences and mathematics. They also have certain restrictions about who can teach in high schools, and some of these restrictions involve certifications obtained from teacher training colleges.

It is becoming increasingly common in industry, and in some colleges, to require the retirement of people from administrative duties and, in some cases, from all duties, at the age of 65 or thereabouts. Is it not possible that some of those men could be of distinct help in improving the teaching situation in high school, even though they do not have teaching certificates? Certain teachers in the teacher's colleges who are listed as specialists are not required to have teachers' certificates. I believe this topic could be profitably explored in more detail. Men who are now hired to teach are very often primarily hired because of their athletic ability, and then, in order to fill their schedule, they are expected to teach something—which may be mathematics or physics.

There is also a growing number of men retiring from active military duty who are looking for things to do.

The Relative Responsibilities of College and High School

What are the responsibilities of the College towards the High School? Rather than have the colleges tell the high school what the high school should do, or vice versa, I think we ought to lay down certain basic principles. The Illinois Department of Public Instruction and the University of Illinois College of Education have considered this matter and have reached the following conclusions:

"Certain principles were agreed upon regarding the respective responsibilities of the secondary school and the college:

"1. The American public high school has the responsibility to develop and administer an educational program which will provide for the education of all youth. . . .

"2. With limited resources, the high school's first responsibility is to provide education of general value to all its students. . . .

"3. The colleges and universities bear the responsibility of continuing the general education of high school graduates and of providing for various specialized needs. . . .

"4. The high school, not the college or university, has the responsibility of specifying the content of the high school curriculum. . . .

"5. The high school has the responsibility of providing colleges and universities with information about its students. . . .

"In the light of these principles, it is recommended that the colleges adopt admission policies which do not specify the courses the students are to take in high school, but specify the kinds of competence to be required of entering students. . . .

"For specialized curricula, certain specified competencies on the part of high school graduates may be required, such as competence in mathematics for engineering. For such cases, the Committee recommends the adoption of the following paragraph:

"Secondary schools are urged to provide means for high school students to acquire, prior to graduation, the competencies demanded for successful work in specialized programs in institutions of higher learning, such competencies to be determined on the basis of standardized tests rather than on the basis of passing specified courses.

"The purpose of the last recommendation is to urge provision in high schools for specialized work really basic to college specialization. The Committee recognizes that smaller high schools will not always be able to provide a sufficient variety of specialized courses to meet the needs for special programs of all its graduates. In such cases, the colleges are urged to make provisions for the basic specialized work with as little handicap to the student as possible."

If these recommendations are to be accepted, the principals, superintendents, and vocational guidance counselors in the high schools must be given advice. Much has already been given.

The Engineers' Council for Professional Development has prepared a pamphlet, "After High School—What?" This has been sent to each high school in the country and it should aid considerably in this guidance problem. They have also prepared a second pamphlet called "Engineering—A Creative Profession." Both are excellent.

The various professions and occupations need more mathematics than they are now getting. Many do not realize where mathematics fits into everyday life. The General Electric Company has produced several pamphlets on such matters as the use of English, mathematics, and so on, which they have distributed to the high schools. They should be helpful. Some professions such as psychology, could benefit from the use of more mathematics than are now used.

The solution to these various problems should be regional and not country-wide. Trying to impose on one section of the country what would be perfectly normal for another could lead to difficulties of a rather serious nature.

The Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science is attacking this problem in a vigorous manner. Industry is also doing its share. For example, the duPont Company in the year 1955–56 will spend more than $800,000 in aid to education. Of this amount, $291,000 has been set aside for the improvement of the teaching of science and mathematics, and $75,000 of this latter amount will be used for summer and winter fellowships for high school teachers who would like to continue for the master's degree.

The Engineers Joint Council, the National Association of Manufacturers, and many individual corporations have all contributed handsomely to this guidance program.

Many of these organizations have distributed to the high schools brochures showing the importance of various scientific subjects to people in all branches of life, including those who expect to go on to college and into engineering. The reception to these brochures in high school has been excellent. Many vocational guidance personnel are now realizing, perhaps for the first time, the general importance of subjects like mathematics.

In addition, various industries have been accepting high school teachers for summer work. This serves the triple purpose of giving the teacher additional income, of giving him a knowledge of what industry is doing and what it needs in those who go to that industry, and also serves as good public relations for the industry. There are other incidental benefits, but these seem to be the principal

ones. Much more of this could be done with profit.

The university or college officials should encourage such activities. They are part of a proper guidance program.

Some colleges have been quite stiff in their dealings with high schools, and have said, in a nutshell, "the high schools will teach these subjects or else we will not admit their graduates to college." In other colleges this viewpoint has been materially changed to permit all high school graduates to enter, with the opportunity to take, in college, for non-college credit, those subjects which are necessary before a student could become regular in college. In general, these deficiencies are of a minor nature and merely extend the period of training in college perhaps one quarter or one semester. There is, naturally, a difference in viewpoint on such matters between State supported and private universities.

Students are very often not getting proper guidance in high school. The right kind of student is frequently not being encouraged to continue to college. Many students are advised not to take engineering in college because of the high failure rate of such students. It is not generally realized that the failure rate in engineering is no higher, as a percentage, than most of the other major professional schools. Perhaps some of the reason for this is traceable to the fact that engineering, on the whole, attracts a better than average intellect.

For some students, the first one or two years of college are frustrating. Such students may have come from high schools or preparatory schools which have a very high standard. When they get to college, some of their first year in college is repetitive. It is clear that if the schools of that type and the colleges could get together, there could be the elimination of part of this duplication—and this is what a few colleges have decided to do. The able student should be expected to travel more rapidly through the college program and perhaps start at a higher level than has been customary in the past. This is common in Europe.

One college with a very interesting approach is the University of Illinois. They have prepared a brochure in consultation with the Department of Mathematics, College of Education, and College of Engineering, which they have been using with the high schools. The University of Illinois is now requiring four units of mathematics as entrance to its Engineering College for full acceptance. The brochure, however, spells out specifically the topics which the students should have in their study of mathematics in high school. This, to me, has a great deal of merit and, in my opinion, should be welcomed by the high schools, although they may consider that this is given from the biased viewpoint of the engineer. It has, nevertheless, the approval of the College of Education. I should like to point out, however, that the University of Illinois gets a very large percentage of its students from metropolitan areas and this is a simpler matter to handle than would be the case in many of the western or southern states.

Dr. Carroll V. Newsom, Associate Commissioner for Higher Education at the New York State University, has proposed a study of High School-College Articulation in Mathematics which is being considered by the ASEE Committee on Secondary Schools.

Career Days

In many states it is customary for the high schools to have Career Day programs. During those programs they expect to have representatives from each of the professions, trades, and other occupations, talk with the students and outline the opportunities in the field and what would be expected of a graduaate. During a year, the engineering staff of Iowa State College participates in a great many of these career days. Each career day is sponsored by one high school at least. However, in general, many high school students from different communities at-

tend each meeting. For example, in the year 1954–55, 446 cities were contacted and 2340 high school students attended the engineering sessions. This is a tremendous increase in interest in a very few years. In one case, Ames High School, the career day program only involved Ames High Students; whereas in another career day program only 32 miles away, 29 cities were represented in that one program. Altogether, there were 46 separate career days attended by a representative from the Engineering Division.

During the career days, the representative from engineering talks about engineering in general, about no particular college, but talks briefly about each of the various branches of engineering, regardless of whether they are taught at his own college. He describes the opportunities and so on. But in the period allotted to him, clearly there are many items which can't be covered, and it has been our practice to pass out cards to the students who attend, so that they would give us some information we would like, but we also give them the opportunity, when they return the cards, to ask about particular programs or to ask specific questions. For each of the departments at our college we have a printed statement of that particular branch of engineering, showing what the graduate might expect to do, where he might live, what his opportunities would be, and so on. We also describe in detail what is expected in each of the fields. This sort of activity is appreciated greatly by the high schools. The vocational guidance men or women in high schools are very often not fully aware of the importance of some branches of engineering; and these are occasionally emphasized at career days, often getting encouraging requests for information.

There has been a tendency to consider for entry into engineering colleges only those students who have high grades in high school. I think this could be a mistake, unless this particular fact is combined with other factors. Low grades in school may be traceable to many things. They may indicate, for example, that the student is not interested in what is taught in high school. There are many students who do far better in college than they did in high school, because for the first time there is a challenge to their mentality. Such students very often get better as the years go along.

In some schools, as in some colleges, there are poor teachers, and they tend to stifle the interest of the student. There is also an occasional lack of motivation of the student who does not quite know what he wants. He may mature later and become excellent. In addition, high scholastic scores are not necessarily indicative of high ability. Thus, we should be careful about saying to a prospective engineering student, "You are not qualified for engineering."

Television and Radio

Some of the colleges in this country either have television or radio stations of their own or have access to such stations and have some knowledge of their operation. High schools frequently have television receivers, and most have, or can get, radio receivers.

We have taken advantage of this situation on our campus to schedule a 15 minute radio interview each week during school days at a definite predetermined time. Each interview gives vocational guidance in the various fields which ordinarily interest high school students. Some of these activities require collegiate training and others do not. But at least we give accurate information to a wide section of the high school student body, and it is appreciated by them. The high schools set aside the period to listen to the program.

On our television station we also put on programs of an educational type showing what engineers, chemists, and physicists do. This is done at night, and has a large audience.

Some time ago at our college, we gave a short course during the summer for

teachers of engineering drawing. I believe this was well received by the vocational teachers in the various technical high schools.

High school administrators must, in the future, demand more intellectual stimulation of the students and more serious work from them. Few high school students in the first two or three years of high school have much, if any, homework to do. This is quite a contrast with what is in evidence in other countries of the world.

Pre-College Examinations

As the flood of students wanting to study engineering begins to appear on the campus, administrators will be confronted with the need for additional staff and facilities. They will not easily be obtained, if my reading of the mood of legislators is correct. Thus there will probably have to be a curtailment in student numbers. I hope this will not be on a first come first served basis, but will be based on quality. This may mean the examination of students sometime during their senior year in high school. This will be a new venture for some colleges, but, in my opinion, will shortly be necessary.

The ASEE Committee on Evaluation of Engineering Education has considered this matter, and has stated in its final report:

"In order to encourage high school-college articulation, it is recommended that a study be undertaken by ASEE in cooperation with professional and industrial groups and societies representing mathematics and the pure sciences for the following purposes:

"1. To determine specific techniques for identifying, encouraging, and developing those high school students who have aptitudes for engineering.

"2. To determine methods for developing adequate study habits and a suitable level of performance in reading ability for those students planning to attend college.

"3. To develop specific techniques of reaching high school faculties and administrators in order to enlist their cooperation in a constructive program to improve the quality of high school preparation, particularly in mathematics, physics, chemistry, and English.

"4. To determine, at each university engaged in teacher training and having a college of engineering, ways of providing advanced study as a part of high school teacher education that would make such teachers more proficient instructors in the subjects necessary for admission to engineering.

"5. To develop specific techniques for presenting these problems and their possible solutions to high school administrators, teachers, and the general public."

It would appear then that instead of constantly criticizing the high schools, we might offer to work closely with them to see if we can solve problems of joint interest. The training of an engineer is not something which starts in the freshmen year in college and finishes four or five years later. The training of an engineer begins at birth and is not completed until his death. It is time, then, that we considered the whole training and, as a first step, I should like to emphasize that college administrators get together with high school administrators and try to work out their problems of mutual interest. In such a spirit of relative good will, I think much could be accomplished.

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
JOHN L. ARTLEY, *Chairman*
Duke University

Editor of YET-itudes
LEE HARRISBERGER
N. C. State College

Getting the YET Message Across

By PETER L. BALISE

Department of Mechanical Engineering, University of Washington

We're Young Engineering Teachers—but what are we supposed to do about it? From the title of this article, the answer apparently is: Get the Message Across—but what message? Why should there be a special idea of Young Engineering Teachers?

Young Engineering Teachers makes no sense if it is just a scheme for having another subdivision of ASEE. But YETs do make sense, and aren't just a subdivision of ASEE. The purpose of the YET idea is simply to help provide an opportunity for younger teachers to take a real part in ASEE and other professional society activities. Such activities are rewarding, sometimes indirectly in dollars, but more important in making worthwhile how we spend eight hours a day or more. Unless a fellow is content merely to shovel out stuff from the text to the student (which might get monotonous after 40 years), he has to keep learning himself. One way to do this is by engaging in research, and another is by reading current literature. Both of these are important, but there is another, very pleasant, way of keeping up to date. That's by getting together with others in professional societies.

Your first thought may be that you're too young and inexperienced to be wanted except to fill another seat in the audience. That just isn't so. They aren't likely to put you up for national society president next year, but any professional organization is looking for the benefits of the eager, inspired, imaginative, enthusiastic, fresh outlook the younger fellows are supposed to have. There are many responsible positions available for younger members, and once you get acquainted by serving on committees, the thing snowballs and you are wanted more and more. One of the chief advantages of professional society activity is getting acquainted, from which you learn what is going on today in engineering and what the actual practical problems are; as well as making it possible to enhance your classes by drawing on visiting speakers and teaching aids you encounter in so-

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."

YET-itudes! Not Platitudes!

ciety activity. Talking with people you meet at meetings can be just as valuable as the papers you hear.

Speaking of papers, probably anyone who's stayed with this one so far doesn't need to be convinced of the opportunities in professional society activity. The question is, how can other YETs be convinced? It isn't going to be done by passing a resolution or printing an exhortation to "get active." A personal contact is necessary, and most of us are not crusaders enough to go around collaring everybody and giving speeches about the advantages of taking an active part in the ASEE or any other professional society.

The purpose of this article is to show how you can have a meeting of the YETs on your campus that will really accomplish something rather than make everybody wish there were fewer meetings he had to attend. And this can be done without bringing in outside talent to amuse and amaze the group. The following suggestions are based on successful experience, not on wishful imagination.

A dinner meeting is best to provide the informal atmosphere conducive to discussion, and is planned as an opportunity for the younger teachers to find out exactly what things are important for successful teaching on the local campus. Who should know this better than the dean and department heads? So they are invited, the dean being asked to give a short, informal talk on the place of professional society activity in your school. Note that this is not a speech title in capital letters; a stirring oration that tells nothing is not the idea, but rather a few remarks from one of the men on campus best qualified to express his opinion.

Of course we hope that someone besides the dean and department heads will come to the dinner. The fact that the boss will be there is an effective inducement to the younger teachers to attend; however, they must be contacted individually. You can invite whomever you want, within reasonable limits, such as all those under 36, which list may be provided by the dean's office. A good plan is to send invitations, individually typed if you can get someone to do the work, asking for a reply by a certain date. Then you take the charge of the campus dining service or restaurant and by well known mathematical technique determine how much each person must pay. You then pass the word that you'll reserve places for those who send you a check.

There is, of course, a variety of ways to handle these details, depending on the situation at your campus. The above method is given in an effort to make this article a source of specific suggestions which you can follow directly. It's obvious that unless you have a local organization's treasury to sponsor the dinner, or want to pick up the tab yourself, the reservations must be handled in a definite manner.

Finally the big evening arrives. This should be more than a day after you first started making arrangements, but not so long that everyone has forgotten what it's all about. It's not much of a job to plan the affair, but you should allow a couple of weeks for getting reservations (i.e., checks) and longer to line up the dean and department heads.

To make things look official (if that's an object) you can provide name tags and a sales talk on joining the ASEE at the door. Of course this, and other suggestions, might be ridiculous at a small school, for which obvious modifications would be made. However, here is a good chance to acquaint those who don't know with the reasons why an engineering teacher should belong to the ASEE.

Having entered the dining room, the people discover that there are place cards, diabolically arranged so that no one sits within reach of others in his department or known friends. This seems a bit arbitrary to say the least, but actually is probably the only way to get most people to sit amongst those they don't see every day. It is usually discovered that the strangers speak English, and a pleasant

conversation ensues, so that the dinner fulfills one of its aims, getting acquainted. Rather than having a mile-long table with you and the dean looking down from a platform at one end, a number of small tables can be used, so that each person meets four or five others quite closely.

Midway in the meal it can be announced that each person will introduce his neighbor on one side. This is an old gimmick that can be very boring, but it can also be entertaining if several people are primed to set the procedure off on a facetious vein. You can show how foolish the idea is at the beginning by introducing the gentleman at your side, who, your colleagues will be surprised to learn, is the dean of engineering.

Before they feel glued to their chairs, it is a good idea to let everybody get up for a short break, perhaps just after the introductions; it should not be necessary to lock the doors. You don't want to be mean and break up the conversation too soon, but eventually the program begins with a few brilliant and witty remarks by yourself.

The dean then gives a brief informal talk, concluding with an invitation for questions. The informality of the occasion is an excellent chance to ask him about his views and policies of the school, which are of real concern to the younger faculty. A good bull session ensues, but must almost invariably be primed at the beginning by planted questions. This is easily arranged if you have any friends on campus.

The many questions which can be so well answered in such a session, the opportunity for learning to know better your colleagues, and the enjoyment of a pleasant evening dining with interesting people make the comparatively slight effort required to plan the affair most rewarding. Try it at your school, and you'll see.

• • •

Here is your September YET-itude: Get the YETs met! The deed is a feed!

College Notes

Bell Telephone Laboratories, research and development organization of the Bell System, has announced the establishment of a fellowship program through which it will grant funds for students doing graduate study in electrical communications.

The awards are for study of one or two years, leading to a doctorate. Each fellowship carries a grant of $2000 to the fellow, and an additional $2000 to cover tuition, fees and other costs to the institution at which he chooses to study. Recipients of the fellowships will not be required to limit their study to electrical engineering, although the field of study and research must have a bearing on electrical communications. They may, for example, pursue various branches of mathematics, physics, chemistry, engineering mechanics and mechanical engineering. Fellows may make their own choice of an academic institution within the United States.

The **George Washington University** has announced the appointment of Dr. Jack Edward Walters to the position of Professor of Engineering Administration.

A combined 118 years of service at **Lowell Technological Institute** ended in June when Prof. Herbert J. Ball, Prof. James H. Kennedy, Jr. and Prof. Martin J. Hoellrich retired.

Survey of Nuclear Engineering Research*

By HERBERT S. ISBIN

Dept. Chem. Eng., Univ. of Minn.; Chairman, Subcommittee on Nuclear Engineering Research, ASEE Committee on Atomic Energy Education

Introduction

Continued advancement of our nuclear science and technology is dependent upon the training of an adequate supply of qualified personnel. The realization of this goal has been one of the objectives of the ASEE Committee on Atomic Energy Education. The Committee has participated in the stimulation of the training and education of engineers in our schools, governmental agencies, and in some industries. This paper concerns the progress being made by our universities and colleges in furthering nuclear engineering research. A report is given of a survey made of all member institutions of the Engineering College Research Council. As a part of its program, the ASEE Committee encourages institutions to develop their educational facilities in the over-all fields involving nuclear engineering, and to contribute to the advancement through basic research. The suggestions contained in this paper, however, represent only the opinions of the author. Currently, the Committee is undertaking a study and clarification of objectives in nuclear engineering and in the methods and scope of the training programs and curricula.

For the purpose of this survey, no formal interpretation of nuclear engineering was attempted. For example, it was indicated that nuclear engineering research topics include the prospecting, metallurgy and fabrication of nuclear fuels, claddings, and reactor structural materials; the design, construction, and operation of nuclear reactors, including experimental studies relating to heat transfer and fluid flow; the study of reactor components such coolants, shielding, instrumentation and control; separations; and fission product utilization and disposal. Almost any basic research problem might be related to some phase of nuclear engineering; therefore, only those researches which were initiated by a *direct* interest in nuclear engineering were sought for the listings in this survey.

Results of the Survey

A summary of the survey is given in Table 1 and the listings of typical research topics are given in Table 2. Table 3 lists the institutions indicating an interest in planning a reactor.

TABLE 1

SUMMARY OF SURVEY ON NUCLEAR ENGINEERING RESEARCH

No. of institutions contacted (all official members of the Engineering College Research Council—1953 Directory)		103
No. of replies		103
No. participating in nuclear engineering research		38
No. with reactor plans		30
* Planning—initial thinking	19	
* Planning—advanced stage	7	
Commitments made	3	
Reactors in operation	1	

* Presented at the Annual Meeting of ASEE, Penn State University, June 21, 1955.

* Of these two groups, ten indicated no current program in nuclear engineering research.

TABLE 2

TYPICAL NUCLEAR ENGINEERING RESEARCH

(Departmental listings are those noted by the Institutions)

Chemical Engineering Department

(including Metallurgical Engineering)

Processing of reactor fuels
Properties of special alloy systems
Radiation-induced reactions
Exchange of deuterium between steam and hydrogen
Catalytic combination of hydrogen and oxygen
Liquid metal research including boiling and condensation heat transfer, thermodynamic properties of vapor, solubility and stripping of xenon, forced and free convection, wetting and non-wetting conditions, gamma ray inspection
Two-phase flow including vapor transport, fluid slurries, hindered settling; pressure drop and heat transfer, and transient operations of natural circulation loops
Thermal diffusion in liquids
Drying of graphite
Swirling flow in spherical and cylindrical containers

Metallurgy

X-ray spectrographic analysis techniques
Recrystallization studies
Constitution of binary alloys of uranium
Scaling of zirconium in air at elevated temperatures
Nitriding of alloy

Civil Engineering

Physical properties of high density barytes-colemanite concrete
Wastes from an atomic energy plant, and disposal of radioactive wastes
Improvement of product for atomic shielding

Mathematics

Investigation of the stability of solutions to differential equations describing circulating-fuel reactors

Chemistry

(Survey of the chemistry departments was not included. The following replies received are pertinent.)

Study of the mechanism of oxidation of metallic sodium
Radiochemical studies of the fission products
Thermodynamics
Isotopic research

Food Technology

Use of fission products in food sterilization

Ceramics

Studies of methods of production of dense concrete
High temperature properties of some intermetallics
Thermal shock studies

Mining Engineering

Special techniques for mining low grade uranium ores

Mineral Engineering

Measurement by tracer techniques of the surface concentration of collectors on iron and lead minerals
Physical characteristics of uranium-bearing Chattanooga shales after thermal treatments

Geology

Use of geochemical techniques in the search for uranium

Aeronautical

Heat transfer

Electrical

Nondestructive testing by use of eddy currents

Physics

Nuclear energy levels; nuclear spectroscopy; neutron diffraction
Gamma ray diffusion, absorption, and slow motion capture studies
Effects of irradiation including damage in plastics and use of infrared in measuring effects
Neutron cross sections and inelastic scattering cross sections
Decay schemes for short-lived isotopes
Dielectric properties of ceramics
Structure and properties of thin metallic films
Slowing-down length of neutrons in reactor materials; neutron age in mixtures
Activation analysis of manganese in blood serum

Determination of gaseous products from a homogeneous reactor
Diffusion of radioactive gases through ceramic layers
Thermal methods for calibrating reactors

Listings Without Specific Departmental Headings

Exploration of the Moyie mountain area for uranium and other minerals
Beneficiation of low grade autinite by floatation methods
Study of field methods for determining the radium-uranium equilibrium in ore samples
Age determination of ore deposits
Uranium ore separations; and uranium and thorium feed preparation
Electrolytic separation of isotopes
Selective isolation of strontium-90, cesium 137 and barium 140
Separation and processing studies of reactor fuels, including studies at high temperatures, and fuels for fast breeder reactor
Study of evaporator for concentrating radioactive solutions
Production of heavy water
Protective coatings on metals; metal-ceramic bonding; high temperature materials for reactors and pyrometallurgy
Fabrication and cladding of fuel elements
Metal diffusion studies; gas-metal studies
Study of creep characteristics
Laminated shielding; admixtures for shielding; similitude relationships in shielding
Slowing down length of neutrons in hydrogeneous media
Reactor instrumentation
Investigation of reactor kinetics
Electromagnetic pumps
University heating
Temperature distributions in metallic heat sources
Effects of gamma radiation on rates of chemical reactions; sterilization of certain injectable pharmaceuticals; on plant tissues in culture; inactivation of viruses; chick feeding studies using irradiated foods
Effects of radiation in producing mutations in seeds; on combustion; sterilization of barley malt; bacterial metabolism; control of trichinosis; and the effects of chronic irradiation on bacterial cultures under conditions of continuous growth
Study of efficiencies in biological systems for the concentration of radioisotopes from liquid wastes
General utilization and packaging of gross fission products
Activation techniques and analyses
Irradiation services on electrical accessories; irradiation of glass, and industrial sapphires

TABLE 3

INSTITUTIONS CONSIDERING A REACTOR

Initial Thinking Stage

University of Arkansas
University of California (Berkeley)
Case Institute of Technology
University of Colorado
Columbia University
University of Connecticut
Cornell University
University of Denver
Georgia Institute of Technology
University of Illinois
Iowa State College
Kansas State College
University of Missouri
Northwestern University
Ohio State University
Purdue University
University of Southern California
A. & M. College of Texas
University of Texas

Advanced Planning Stage

Alabama Polytechnic Institute
University of California (Los Angeles)
University of Florida
Massachusetts Institute of Technology
University of Utah
Vanderbilt University
Washington State College

Commitments Made

Illinois Institute of Technology
University of Michigan
Pennsylvania State University

Reactors in Operation

North Carolina State College

Discussion of Results

The survey serves to reflect the active interests displayed by our universities and

colleges in participating in the development of nuclear engineering. More than one-third of the institutions have active research programs. The typical research projects listed in Table 2 outline the areas of current activities. In particular, the contributions that can be made by institutions not having a reactor are noteworthy.

The number of institutions considering a nuclear reactor for their educational and research programs is proportionately large. About 10% of the member institutions of ECRC consider their reactor planning in an advanced stage or have already made commitments. North Carolina State College is the only institution now operating a nuclear reactor.

The role played by the institutions in the development of nuclear engineering is not to be judged solely by their research activities or reactor plans. An additional 10% noted that they were active in one or more of the following ways:

1) Participants in an AEC National Laboratory
2) Developing courses in nuclear engineering
3) Staff members acting as consultants
4) Cooperating with industrial groups in the development of curricula and granting of degrees.

Suggestions

We recognize that almost all established engineering departments will make major contributions in nuclear engineering. As shown by Table 2, a larger share of the research is to be encouraged in the mechanical, civil, aeronautical, and electrical departments. Classification of research by subject material is the desired objective, and to some extent, this was incorporated in the departmental listings.

No attempt is made to analyze critically the progress being made in research. It is worthwhile, however, to note AEC's strong interest in high temperature chemistry and material problems (W. F. Libby, *Chemical and Engineering News*, 33, 1944–5, 1955), and the general need for more research in problems relating to physical metallurgy, chemical separations, and fission product utilization and disposal. An effective way to feel the pulse of the unclassified and declassified research in all fields is to examine the current issues of *Nuclear Science Abstracts* (publication of the U. S. Atomic Energy Commission Technical Information Service).

The need for training and exposing faculty to nuclear engineering developments has received considerable attention by the AEC National Laboratories. Programs involve extended or summer work at the Laboratories. To a limited extent, even an exchange of personnel is possible. Staff members who have participated in these programs have been able to initiate and continue research at their institutions.

The laboratories required for nuclear engineering education and research have, for the most part, been directed toward a nuclear reactor. (Related research in nuclear physics is not considered in this paper.) High costs, availability of enriched fuel, and the AEC's high standards represent the factors which will self-regulate the number of institutional reactors. Serious consideration should be given to alternate proposals. Work with exponential piles and other subcritical assemblies provides excellent training. Further, the development of reactor kinetic simulators and analogs represents worthwhile objectives.

One might well anticipate that the major growth in nuclear engineering will appear in the irradiation and separation studies. The separation, utilization and disposal of radioactive products involve laboratory facilities which are highly desirable from standpoints of both educational training and research. In fact, the potential value of these installations rivals that of a research reactor. Thus far, only a few institutions have gone in this direction.

Institutional participation at the National Laboratories is provided, along with

equipment that can be used in the development and training of graduate engineers. Again, only a few institutions have taken advantage of the opportunities. Perhaps a reappraisal of a school's needs will show the advantages of developing one or a few special educational and research facilities on campus. The laboratory installations can then be utilized to achieve the broad perspectives generally desired in nuclear engineering.

Summary

The survey revealed that an encouraging proportion of our institutions is participating in nuclear engineering research, and that a corresponding large fraction has interests in a nuclear reactor. Several personal suggestions have been offered to emphasize the desirability of needs other than a reactor, and to note some of the opportunities available at our AEC National Laboratories.

College Notes

A class of 27 college engineering instructors from 23 states and two foreign countries studied advanced highway engineering this summer with the Institute of Transportation and Traffic Engineering of the **University of California, Berkeley.**

Street and highway construction is accelerating all over the country and is expected to continue to increase in the foreseeable future. The shortage will be even more acute when Federal legislation for better interstate highways is adopted. The summer instruction program at Berkeley was designed to aid other colleges and universities in expanding their teaching of highway engineering so that enough men can be trained to fill the many jobs now open in the highway profession.

Harold M. Froslie, head of the physics department at **South Dakota State College,** has been appointed acting dean of engineering. Dr. Froslie became acting dean July 1 and will serve until a new dean is appointed or until June 30, 1956.

Professor Edwin R. Shorey, College of Engineering's Department of Mining and Metallurgy, retired from the **University of Wisconsin** at the end of the 1954–55 academic year.

Dr. Willibald Weniger, **University of Alaska,** has retired as Head of the Physics and Electrical Engineering Department.

Science has become the greatest cultural force of our times, declared Dr. John Day Larkin, dean of liberal studies at **Illinois Institute of Technology,** in a Chicago commencement address. Because of its very complexity, a scientific and technological society requires some specialization, pointed out Dr. Larkin. But, he cautioned against too narrow a field of specialization which would make the individual lose sight of a common heritage and common problems as a citizen.

The **University of Florida** Department of Civil Engineering and the Prestressed Concrete Institute will sponsor the First National Prestressed Concrete Short Course October 10 through 12 at the Maritime Base, St. Petersburg, Florida. Theory and design will be discussed in lecture classes and papers will be presented by engineers in the prestressed concrete field.

Dr. Sydney Goldstein was appointed Gordon McKay Professor of Applied Mathematics in the Division of Engineering and Applied Physics at **Harvard University.**

Report on Survey Conducted by Committee on Recognition and Incentives for Good Teaching*

By HARRY W. CASE

University of California, Los Angeles

During the past year the Committee on Recognition and Incentives for Good Teaching undertook as part of its work a survey of the member collegiate institutions of the ASEE in an attempt to throw further light on the present status of teaching in the engineering colleges. It was hoped that this survey might furnish information which would be useful in attempting to determine, among other things, whether 1) teaching is receiving its correct proportion of attention in the multiplicity of professorial activities, 2) teaching is being encouraged as a profession, 3) attempts are being made to develop teachers, and 4) a good job of teaching is being rewarded adequately and appropriately.

The questionnaire was distributed to all members of the ASEE. From the first run 114 replies were received—69 from public institutions and 45 from private educational centers. A follow-up letter was sent on May 27 to 17 institutions which had failed to reply to the first distribution of the questionnaire. The results of this follow-up letter are not included in this report.

Table I shows the breakdown of the data by percentages. The data have been grouped into three categories—public schools, private schools, and the total group of schools. It may be advisable, when all of the information is received from the schools that failed to respond to the first survey, to attempt to make a regional analysis based on large geographical sections, such as East Coast, Midwest, etc. The regional breakdown used by the ASEE was utilized and found not usable because of the large number of regions involved and the small number of schools in a region, in some instances.

It will be noted in the examination of Table I that in numerous instances some of the questions were not answered. Unfortunately, it seems almost impossible

TABLE I

PERCENTAGES OF REPLIES

		Public	Private	Total
Question 1	Yes	39%	25%	33%
	No	58%	71%	63%
	No Answer	3%	4%	4%
Question 2	Yes	38%	28%	34%
	No	62%	64%	64%
	No Answer	0%	8%	2%
Question 3	Yes	56%	51%	54%
	No	34%	36%	35%
	No Answer	10%	13%	11%
Question 4(a)	Yes	47%	31%	40%
	No	33%	45%	38%
	No Answer	20%	24%	22%
(b)	Yes	10%	13%	11%
	No	57%	54%	56%
	No Answer	33%	33%	33%
(c)	Yes	43%	44%	44%
	No	35%	36%	35%
	No Answer	22%	20%	21%
Question 5	Yes	16%	18%	17%
	No	81%	73%	78%
	No Answer	3%	9%	5%
Question 6	Yes	61%	60%	60%
	No	36%	38%	37%
	No Answer	3%	2%	3%
Question 7	Yes	71%	75%	73%
	No	16%	18%	17%
	No Answer	13%	7%	10%
		N=69	N=45	N=114

* Presented at the Annual Meeting of ASEE, Educational Methods Division, Penn State University, June 20, 1955.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

COMMITTEE ON RECOGNITION AND INCENTIVES FOR GOOD TEACHING

Mail to: Professor Harry W. Case
Department of Engineering
University of California
Los Angeles, California

QUESTIONNAIRE: Recognition and Incentives for Good Teaching

(1) *Local Committee*

Within the last two years has a committee at your institution made recommendations on the problem of recognition and incentives for good teaching with emphasis on good teaching as distinct from other activities? Yes..... No.....

(2) *Attention to Good Teaching*

Has your institution developed any good methods for calling attention to good teaching other than through rank and salary promotions? Yes..... No.....

(3) *Publicity on Good Teaching*

In publicity and house publications does your institution place emphasis on good teaching at least equal to the emphasis placed on each of the following: plant, research, science and technology, and social or professional activities? Yes..... No.....

(4) *Periodic Evaluation of Individual Growth*

Does your institution require a periodic report on activities reflecting growth of each member of the teaching staff to be made by:

(a) the staff member? Yes..... No.....
(b) a committee? Yes..... No.....
(c) an executive? Yes..... No.....

(5) *Consultation with Teachers on Effectiveness*

Does your institution require a periodic consultation with each teacher on the subject of his teaching effectiveness? Yes..... No.....

(6) *Written Policy Statement*

Is a written statement of policy on rank and salary promotions for the teaching staff available to the staff at your institution? Yes..... No.....

(7) *Weight on Teaching Effectiveness*

When your institution considers a member of the teaching staff for rank or salary promotion, do you believe that in most instances more than half of the weight of decision is based on the individual's relative teaching effectiveness? Yes..... No.....

Institution.....

Name.....

Position.....

Date.....

to design a questionnaire of this nature which will cover satisfactorily all possible cases, and make sense to the individuals answering it. Considerable improvement undoubtedly can be made if such a survey is undertaken again.

The members of the Committee would like to thank the very large number of deans who took the time to fill out the questionnaire personally, and who in many instances made written comments on the areas being considered. It seems desirable to go over the seven questions comprising the questionnaire and to call to your attention some of the results and the comments made by the various institutions.

(1) *Local Committee*
Within the last two years has a committee at your institution made recommendations on the problem of recognition and incentives for good teaching with emphasis on good teaching as distinct from other activities?

A higher percentage of publicly owned schools answered that they had committees than did privately owned schools. The total is almost two to one of "no" answers to "yes" answers. The remarks range from apologies for poor and inadequate college committees to the statements of those who pointed out that they had had committees in the past but did not at present. A comment from one of the schools indicated that they believed they were small enough to do without committee action. Still another dean commented that the entire faculty of professors constituted the committee. Other comments were that it was primarily the young teacher who was interested in this objective; and another indicated that teaching was only one of six fields of emphasis.

(2) *Attention to Good Teaching*
Has your institution developed any good methods of calling attention to good teaching other than through rank and salary promotions?

Again, public institutions were somewhat better in this respect than the private ones. Only 34% of the schools indicated that they had some method of calling attention to the individual instructor; 64% indicated that they did not. One college has an annual $1000 award for "able and inquiring teaching," and another gives a medal. Comments ranged from the desirability of such a system if it could be worked out to the feeling that it was extremely difficult to develop such aids.

(3) *Publicity on Good Teaching*
In publicity and house publications does your institution place emphasis on good teaching at least equal to the emphasis placed on each of the following: plant, research, science and technology, and social or professional activities?

The results from this question are somewhat more encouraging. Of the overall total, 54% place emphasis on good teaching equal to other activities; 35% do not; and 11% did not answer the question. Comments on this question ranged from one which stated, "Teaching ability is emphasized to the exclusion of some of the above," to those which remarked, "It is difficult to publicize," or "It cannot be measured." "The implication of this seems to me to be ridiculous," was one blunt reply.

(4) *Periodic Evaluation of Individual Growth*
Does your institution require a periodic report on activities reflecting growth of each member of the teaching staff to be made by:
(a) the staff member?
(b) a committee?
(c) an executive?

A glance at Table I will reveal that the "did not answer" group increased mark-

edly in this question—the implication being that the answers were not needed in all sections of the question. Apparently, the way the question was designed confused many of the individuals completing it. Forty per cent of the group indicated a "yes" to section (a), that the staff member was required to make a periodic report on his activities; 38% answered "no"; and 22% did not answer. Eleven % of the total required such a report to be made by a committee, while 56% did not, and 33% failed to answer. Evaluation by an executive received 44% "yes" answers against 35% "no" replies, and 21% did not answer. The comments on the question ranged from the statement that the staff member was "expected to" on item (a) to "indirectly" on item (c). One dean pointed out that the committee was rather informally organized by department heads and deans. Another said that the executive committee made such a report annually, and one pointed out that steps are being taken at present to compile personnel record folders which will contain evaluation and progress reports.

(5) *Consultation with Teachers on Effectiveness*
Does your institution require a periodic consultation with each teacher on the subject of his teaching effectiveness?

The "yes" responses to this question showed a very heavy drop, percentagewise. Only 17% of the schools responded affirmatively, while the majority—78% —answered "no." Five per cent did not reply. The majority of comments indicated that when consultation was held with teachers on their effectiveness, it was done informally. In some instances this occurred only if the teacher was "low" or a young teacher just getting started. One school stated that since they were small, they had the advantage of being familiar with the work of all individuals and that they consulted with their teachers. Another school commented that they had done so in the past, but did not have definite plans for the present year.

(6) *Written Policy Statement*
Is a written statement of policy on rank and salary promotions for the teaching staff available to the staff at your institution?

Sixty per cent of the total schools reported that they had a written policy statement on rank and promotions available to faculty and staff. Thirty-seven per cent did not have such a statement available, and 3% failed to answer the question. Comments on this question varied all the way from the statement of one dean who said, "Yes (my own)" to those who have them in preparation at present. Probably one of the useful indications of the trend was the comment from a dean who wrote alongside the question that he would like to receive a copy of such a statement from an institution which had one.

(7) *Weight on Teaching Effectiveness*
When your institution considers a member of the teaching staff for rank or salary promotion, do you believe that in most instances more than half the weight of the decision is based on the individual's relative teaching effectiveness?

In the responses to this question, private institutions fared somewhat better than the public ones. Seventy-three per cent of the total answered "yes" that they believed that more than half the weight of the decision is based on the individual's teaching effectiveness, 17% answered "no," and 10% did not answer the question. The comments in many instances reflected the conscientious viewpoint of the answerer by qualifying the answer with the statement that this was an ideal to be sought but often varied in the actual cases. One individual, for example, who refrained from answering, stated that he would like to think so, but that he was

not sure. Another one said, "Sometimes 'no' and sometimes 'yes.'" Still another one pointed out that there were ten factors involved in an appraisal at their institution, and that teaching accounted for 35% of the weight.

Looking at the answers to the questionnaire as a whole, it seems that "good teaching" is a quality which is desired by most institutions but which is found difficult to measure. The number and quality of publications a man has to his credit for a year, the number of committees on which he serves ably, the number of hours he teaches, the amount of time he devotes to civic activities, etc. can be measured more definitely. Colleagues can assess the value of the publications, the work done by the committee and how much of it the individual is responsible for can be ascertained, the schedule of his classes is easy to determine, and his civic activities are not too difficult to find out about; but how does one determine *objectively* how "good" a teacher a man is? This seems to be the crux of the problem. Students can be polled, but can student opinions of teaching effectiveness be termed anything but subjective? Other teachers' opinions can be obtained, but these are not only subjective but also are based mainly on hearsay from students, either directly or by inference. The amount of difficulty students have handling a course can be considered only in relationship to the background of the students—some may be ill-prepared and some may not have the basic aptitude. Effective teaching is, therefore, a quality or ability which needs to be studied more thoroughly in order that an objective method of evaluating it may be determined.

Yet, in spite of these problems, it is obvious that engineering colleges over the nation are not only aware of the necessity for recognition and incentives for good teaching, but individually are attacking the problem. Undoubtedly, there is much to be done; however, the recognition that other schools have not only attempted to solve their problems but have worked out methods to do so should do much to spur on others. It is apparent that if the engineering colleges which are unable to feel satisfied with their efforts along these lines were to concentrate on establishing for their schools policies and procedures which would include attention and publicity to good teaching, periodic evaluation of individual growth, and a written statement of policy on rank and salary promotions giving definite weight to teaching effectiveness, there would of necessity be a great upsurge in the recognition and incentives for good teaching.

Perhaps now that we know there are schools leading the way in these efforts, an interchange of information could take place which would reveal many of the pitfalls that others have surmounted. One area in which public exchange of information could be useful is in the development of a written policy statement concerning rank and salary promotions. Another is the ways and means of affording publicity to good teaching. Practically all the factors touched on in the questionnaire are important to other schools; and if those who have explored these byways will make known to others their results, much will have been accomplished.

Aim for Ames in 1956

What Industry Expects of the Young Graduate Engineer*

By JOHN GAMMELL

Director of Graduate Training, Allis-Chalmers Mfg. Co., West Allis, Wisconsin

Part I

I had occasion about a year ago to ask some prominent engineers and industrialists what they thought could be done by our schools to prepare better engineers. I will give you, briefly, some of their ideas plus a few of my own opinions.

As you might expect, their suggestions strongly mirror their own interests. The ideas are good but present no obvious unified point of view. Collectively, they indicate a need for adaptable people with broader educations. They emphasize, too, that college is but a prologue to a useful career. A good education is one that stimulates a man to continue growing in whatever direction is necessary.

This can best be illustrated by a few quotations from these letters.

Practical Engineering Must Never Lose Sight of Economic Factors

Those in management believe a professional engineer must never lose sight of the economic factors. For a man who has to carefully scan the profit and loss statement every month, such ideas are far from trite, though they may seem that way to the rest of us. Here then is what was on the mind of an industrialist who started his own business and carried it on to success.

"From the standpoint of industry, I believe an engineering education should include an economic analysis of an engineering problem stated in terms of material and labor reduced to dollars and cents."

A few years ago, industrial magnates were everywhere deploring that our youth were being led down the road toward that "bugaboo" of the rugged individualist—the welfare state. They had a point too. One of them quotes an excerpt from the American Ordnance Association published in 1948 under the title of "Are We Owed a Living?" in which he shows that it costs the nation's taxpayers $25,000 (as of 1948) to educate and protect a child from the time he enters kindergarten until the time he graduates from college. The emphasis he makes is, that these students ought to be made aware of how much they owe other people; that they aren't aware of it and aren't properly grateful.

Continued Professional Development

Few comments are more monotonously repeated among engineers than the one about the need for professional development; I could hardly leave such a quote out of my paper. Here is a typical one from a scholarly elder statesman with a genuine interest in young men.

"There are however changes that appear on the horizon that will make it necessary to consider the engineer as a truly professional individual. The training of such professionals will require a broader education than the conventional four-year course in engineering provides. It would appear therefore that consideration must be given to a broader appraisal of engineering education regarding professional development, and it must be

* Presented at the Annual Meeting of ASEE in the Joint Session of the Mechanical Division and Relations with Industry Division, Penn State University, June 21, 1955.

clearly and definitely understood that there is a difference between the technologist and the technician."

Somewhat contrary to this, a chief engineer of high stature has this to say:

"The present four-year course is ample. I do not favor a five-year course or advanced courses for general engineering work. I favor training men in the location where they will work as more beneficial."

Personally, I feel the training a man gets just by working in the location of his job is limited. It seems to me that this is merely learning the job routine. For instance, if I wanted to train a turbine designer, I would see that he erected a turbine; tested one; understood power house procedures; etc., as well as just knowing design calculations, which he will assuredly learn well since he'll do them the rest of his life.

The Experienced Older Engineer Needs Different Skills Than the Beginner

Comments from several heads of engineering and research sections indicated that success as engineers was not due to technical skill, but rather to such elusive factors as personality and professional development. This is another of those highly overworked statements among engineers, yet the next quote fascinates me —it's clear-cut.

"Generally, it is safe to say that technical ability and proficiency has its greatest value early in the career of an engineer. At that time, it is a substitute, often a very superior substitute, for experience. It can even substitute for judgment and personality. With the years, however, and with longer practice in engineering, the scope of the individual is broadened. Technical ability loses its importance and the personal characteristics of the engineer play an ever-increasing part in determining his progress."

A successful executive who is now in the process of establishing his sphere of influence is most concerned that young engineers continue to grow professionally. He has this to say:

"An engineer must never stop educating himself in the field of modern industry.

"After the future engineer in industry completes his formal engineering education, he should consider the planning of time for additional studies so that he may continue to broaden his background."

It is an important idea, and I intend to close with a quotation on the subject of continued education.

Research Heads Want Fine Basic Knowledge and Engineering Creativity

Research people are full of ideas and, traditionally, are supposed to be able to improve anything. Here is a remark by a research head (a Ph.D.) right up to date on the latest in curricula ideas. He's critical and points out:

"In the last forty years industry has changed more perhaps than in the previous hundred years, yet it has been reported that in most engineering colleges the curricula in at least civil, mechanical, mining, and electrical power engineering have not changed materially in that time. Since engineers are trained primarily for industry, it would seem that with the revolutionary changes going on which make industrial processes more scientific and more highly technical, the engineering courses should have been changed to adapt them to industry's needs."

To accomplish this, he proposes a thorough four-year, undergraduate drill in fundamental science and general engineering.

Another head of a development and research organization is concerned with the creativity of young men. He states,

"I would say that one of the real problems facing industry today is securing engineers not only trained to think along the lines of the so-called 'engineering method' but also to secure men who have some basic training in creative methods."

When talking creativity, I sometimes have a "puckish" tendency to remark that what we need is some good maintenance technicians. There are so many electronic

devices and other gadgets (dreamed up, no doubt, by creative individuals) around my house now that I can't get repaired, I'm a bit disturbed about getting any more.

Humanities Should Be Stressed

There is a well-known school of thought among management people which stresses the need for men with a better understanding of the humanities, cultural subjects and business; in other words, knowledge other than scientific. I suspect they feel we may all end up as a special kind of robot requiring a nutritional pill or a health shot now and then to keep us mechanically creating all those machines we have trouble maintaining. They might even be able to give us these health shots and nutrition pills with an oil can, thus further extending the allusion. Here are two quotes on the humanities, one by an old timer with experience and influence,

"Courses in Public Speaking, Business Letter Writing, Commercial Law and Essentials of Advertising could be advocated as electives for engineers."

another by a prominent consultant in management:

"The recognition of humanities is desirable. Too little thought is given to the developing of imagination and creativeness."

A Young Engineer Speaks on Dangers of Specialization

The present day trend toward the training of strictly technical specialists is deplored by a young man climbing the ladder of success. This young man, who is just starting out on his professional career, but who already has attracted much attention for his leadership qualities, suggests

"that juniors and seniors be more positively encouraged to read technical publications, attend professional lectures, and generally begin to integrate themselves into the engineering community. (Professional societies.)

He continues:

"The great shortcoming of engineering training lies in its failure to direct the student's attention to studies complementary to his technical courses. Often, we graduates discover ourselves to be, a year or so out of college, skilled in a trade, conversant with the phenomena of science, staunch of character, sociable, and somewhat uneducated. We are ill-prepared for leadership of—or even intelligent participation in—the society technology has developed."

This particular young engineer makes out quite a case against those who want too early specialization. He quotes rather learnedly from Jacques Maritain, a Harvard philosopher.

"Specialization is more and more needed by the technical organization of modern life, yet it should be compensated for by a more vigorous general training, especially during youth. If we remember that the animal is a specialist, and a perfect one, all of its knowing-power being fixed upon a single task to be done, we ought to conclude that an educational program which would only aim at forming specialists ever more perfect in ever more specialized fields, and unable to pass judgment on any matter that goes beyond their specialized competence, would lead indeed to a progressive animalization of the human mind and life."

Along these lines it is pointed out by some that the honeybee is a perfect example of the result of a specialized society. It has no other objective and no other function than one assigned to it by reason of birth. It carries this on with great perfection until it dies. Its society is perfect, but it isn't human and it doesn't advance.

From the foregoing, it is easy to see that people feel deeply about what the young engineer should be like and the training essential for engineering success. The most interesting part is the diversity of requirements. Because of this, a friend of mine, deeply interested in the training of engineers to meet tomorrow's challenge, feels that 5 or 6 years of academic training is essential for the engineer of the

future. Whether the extra one or two years turns out to be in graduate school or undergraduate school; whether the humanities are added in the beginning or interspersed throughout the course in college, is something to be debated, but the final result is, he thinks, inevitable—we need 5 or 6 years college work. At the same time, however, one cannot escape the notion that if industry wants specialized people, they should do more than on-the-job training which is frequently not real education at all, but just learning the job. The honeybee, of course, knows its job, but, knowing nothing else, it doesn't "grow."

Part II

Although the survey did not enlighten us as to what industry expects of the young engineer, it nevertheless made us aware that industry likes young engineers to be in their own image.

A careful analysis of the replies, however, shows some agreement in the area of intangibles. They are not factors which can be taught in specific courses, but rather the young man imbibes these ideas from the environment (home, community, and school). The ideas are not new, but because of the pressure on the schools to present the ever growing mass of technical knowledge, the realm of philosophical thoughts is neglected. Yet it is the young engineer's philosophy toward work and dealing with people that looms so large in his progress toward success.

I shall briefly discuss some of these factors as I see them.

The Man Makes the Job

There is a philosophy found among many young men and also in the college faculty that would seem erroneous. It arises from a notion quite prevalent in professional circles, too. This is the notion that jobs must somehow measure up to the man—that it is unethical to employ a talented, high grade man and put him on a task not in keeping with his training and skills. Doesn't a feeling like this indicate that we have missed the true meaning of education? The true professional, the creative man, the man of imagination can take any job, no matter how menial, and turn it into an activity which measures up to his own standard. Thus, we have the blacksmith becoming a metallurgist; the carriage maker becoming the automotive engineer; the crystal set radio maker becoming the electronic guided missile specialist; or, to go further into history, the laboratory helper discovering some of the basic laws of electricity and magnetism.

It has been facetiously remarked that a good man given a broom and asked to be responsible for keeping the place clean will bring a lot to the janitorial business. There is some merit to this point of view, since a casual glance at developments in the field of janitor's supplies indicates that a great deal of fine engineering has gone into the business. While it is stretching the point, an engineer should have the enthusiasm and the confidence to say, "Give me any job—any job at all—and I will make something of it, for that's the way I've been educated."

Benjamin Franklin must have had thoughts like these when he walked the streets of Philadelphia with a loaf of bread under his arm, and Ben Franklin illustrates exactly the point I mean to make—you could give him a job, any job at all, science, politics, the printing business, or anything else, and his attitudes and abilities were such as to bring it to a high order of usefulness and esteem. We are not a status quo society; we are a moving, growing society! Things of today that amount to nothing are going to be of top importance tomorrow. To meet the rapid changes in our economic and social life, highly adaptable men with imagination are needed.

Much of the present talk, therefore, on better utilization of engineers—though it must be admitted not all of it—seems to be as out of place with the needs of our dynamic new world as a group of revived

Roman Senators discussing Ceasar's Empire.

Loyalty

We often receive complaints that the young men of today are not loyal to their employers. This lack of loyalty might arise from the poor utilization idea. To exaggerate a bit, if they cannot immediately walk in and become Manager or Chief Engineer, they feel frustrated and become a "bad apple in the barrel." They don't like the place and, seemingly, don't want anyone else to like it either. They should realize that when they agreed to sell their services, they also agreed to be loyal to their employer. And loyalty means that they will do the best they can, and neither do or say anything that will be of detriment to their employer Communicating unconstructive dissatisfactions to fellow workers should be avoided.

This does not mean that nothing should be mentioned about problems and gripes. The young men will have to take over management in later years; they should think about the difficulties now.

Management Ability Needed

According to some authorities, approximately one in every two graduates from an engineering college, today, is destined to be in an executive position in the not too distant future, while many others, although not executives, will be in a supervisory capacity and be responsible for subordinates almost immediately. This being true, an understanding of a few basic principles of management is in order. A successful supervisor becomes a receiver of ideas rather than a dispenser of ideas—a servant rather than a master. He wields influence by asking questions and receiving information, rather than by giving orders and acting as a "know-it-all" (an irritating business to a subordinate who probably knows more of the detail than his boss.) He should take a genuine delight in his subordinates' successes—might even brag about them a little; he finds satisfaction in helping others out of trouble; he defends his subordinates vigorously; he expects nothing but the warm glow within himself when discovering a job well done by a subordinate and thereby discovers the real law of compensation in human affairs. I think this is well summed up in the quotation from the *BIBLE* (Mark 9:35)

"If any man desire to be first, *the same* shall be last of all, and servant of all."

The Courage to Stand by One's Ideas

To have the courage to propose ideas and to defend them should be an integral part of a young man's training. (Does anybody really like a yes man?) He should not do this, not only because he will eventually become older and assume more responsibility, but because he will have the responsibility even as a young man to influence his superior toward better and more modern methods. Isn't this a traditional requirement for young men? It is a phase often neglected during the training of young engineers. To illustrate my point, I would quote from an article in the January–February 1955 issue of *Harvard Business Review.* Speaking of executive engineers, it says:

"They get too busy with the technical details to worry about developing people—and this is more true of able engineers than of mediocre ones. Since their ability and knowledge is great, assistants lean on them for ideas and decisions to too great a degree. The junior men do not learn to fight hard enough for chances to try their schemes, and too slowly develop a sense of responsibility for the wrong and right. Having too little experience in making mistakes, they are also slow in developing the courage to risk mistakes and defeats—an indispensable quality in modern management.

"The delegation of authority and risk taking seems to be better understood by nonengineers. It is difficult for almost all bosses to let the man of less experience and ability make decisions; it looks like a silly risk."

While a few may temporarily make fine careers by constantly saying "Yes" to the boss, and perhaps "No" to the help, it is a method which sooner or later will lose the respect of everyone. To fight for your ideas is a mark of any strong person. It is a hazardous operation however, and must be accompanied by a keen sense of discrimination, as it can easily ruin the career of a promising young man, yet is a risk that he must be taught to take —there is no other course.

Profit and Loss in Business

Any man in business must have some appreciation of the importance of the profit and loss statement. From a business standpoint, what can be more important? The story is told of an important executive who was being pushed by his President to operate an outlying plant in a manner different than he wished. After quite a bit of debate over the subject, the Plant Manager said, "Mr. President, if I do what you want me to, and the plant is in the red next year, will you send me a letter of congratulations?" Another over-simplification, no doubt, but the meaning is clear—you have to be in the black in any business operation, and it is your responsibility to see that your superior knows and thoroughly understands the implications of his orders. If you are in the red, you will be blamed for it regardless of what those orders happen to be. It is like the lines of a familiar poem:

Laugh and the world laughs with you,
Weep and you weep alone,
For the sad old earth must borrow its mirth,
But has trouble enough of its own.

Understand the Boss's Problems

Many young men become discouraged when they present an idea to the boss and his attitude is doubtful. Why shouldn't the boss be doubtful? The idea is new; he therefore asks questions. To the young engineer who has lived with his problems a long time, this irritating question period seems pointless. He assumes that his superior is negative with regard to his project. He becomes unnecessarily discouraged.

Continued Education

Continued education is important but even Thomas Jefferson sometimes had doubts about certain kinds of education. At one time he said:

"They (academies) commit their pupils to the theatre of the world, with just taste enough of learning to be alienated from industrious pursuits and not enough to do service in the ranks of science."

But does anyone really think too much education is possible? To believe this is, in a way, like saying it is possible to be too wise. Students, however, should be made to realize that going to school without a goal is a hollow thing; and that many a bum on a park bench is well informed. Wide knowledge is not necessarily a mark of men of great accomplishments. Someone has said that a good definition of an educated man is one who knows a little bit about everything (quite an undertaking) and a great deal about one thing.

Motivation

It is a characteristic of an engineering education that it conveys to a man a respect for facts and objective thinking. Respect for facts may prove detrimental when a man is called on to make decisions. A recent article on management pointed out that by the time all the facts have been gathered, the need for decision-making has evaporated. After all, many decisions are made on the basis of how we feel —in short, our emotions rather than a complete factual analysis. It has been facetiously remarked, "Any married man knows this, but do engineers?"

A young engineer is certainly most valuable who understands that the drive to *do* something worthwhile is more important than whether or not he *knows* something worthwhile. The will to get there is the vital part. To repeat the words of an English poet:

Grant us the will to fashion as we feel,
Grant us the strength to labor as we know,
Grant us the purpose, ribb'd and edged
With steel—to strike the blow.
Knowledge we ask not—knowledge thou has lent,
But Lord, the will—there lies our bitter need. . . .

Conclusion

In closing, let me quote from the writings of James Hilton, the creator of that fine literary character, the schoolmaster, Mr. Chips. It is entitled "The Day Mr. Chips Got Mad" and might be appropriate to this discourse on what industry expects of the young engineer. It starts out with something from Epictetus—

"'It is impossible for anyone to begin to learn what he thinks he already knows.'

"Mr. Chips wasn't often cantankerous, but he did once (and perhaps a bit unfairly) let fly over a letter from a parent containing the sentence: 'After my son finishes his education, he will enter my business.'

"It was the whole idea of 'finishing an education' that did it. 'Good heavens,' he exclaimed, 'does the fellow think education is like measles—something you get over while you're young so that you don't have to be bothered with it ever afterwards?' And then came the quotation from Epictetus, as above."

I daresay Epictetus, like Mr. Chips, exaggerated a little to make a point. But it is a point worth making—that education, in the deepest sense, is continuous and lifelong and in essence unfinishable; and it is true also that what we think we already know is often less helpful than the desire to learn.

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Teaching Tips

The cooperative spirit between student and teacher, so necessary for good instruction, is greatly enhanced when the teacher knows the students as individuals. Often this is not accomplished until too late in the course to be really effective.

One way to accelerate this acquaintance is to ask (at the first class) each student to prepare a short biography for the benefit of the instructor. These should then be read and studied by the instructor. They aid him in associating names and faces and in treating these names and faces as an individual with normal ambitions, strengths, and weaknesses.

Such biographies should include background experiences in schools, army or industry rather than dates. Likes and dislikes are also important, as well as weaknesses that are recognized by the student.

This plan might back-fire unless the instructor is sympathetic and wise in the use of the information given. Properly used, however, it has much to offer.

FRED H. PUMPHREY

College Notes

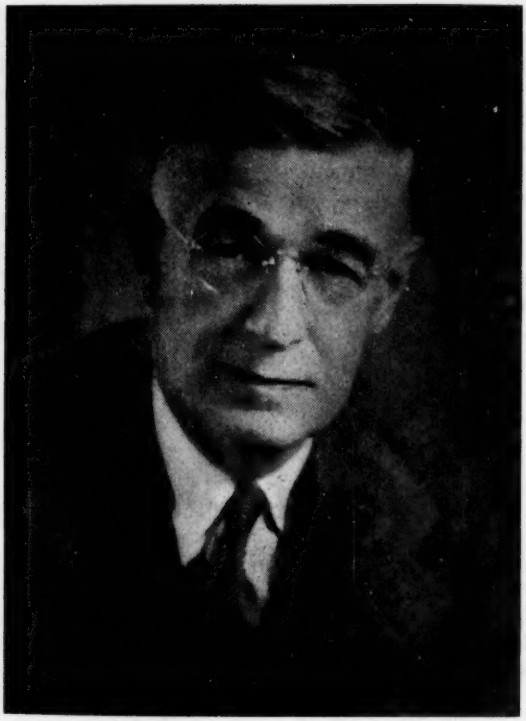
Dr. Paul Weber, Professor of Chemical Engineering and Director of the School of Chemical Engineering at the **Georgia Institute of Technology,** has been appointed Dean of Faculties.

Dr. George V. Smith was appointed to the Francis Norwood Bard Professorship of Metallurgical Engineering at **Cornell University.** Dr. Smith has taught graduate night courses in metallurgy at Brooklyn Polytechnic Institute and was a research metallurgist with the U. S. Steel research laboratory.

Two new graduate courses in nuclear engineering are being offered at **Oklahoma A. & M.** during the 1955–56 academic year. The college has an arrangement with the Argonne National Laboratory for graduate students to take their courses at Oklahoma A. & M. the first year and work for the Atomic Energy Commission at Argonne the second year. These graduate students will write a master's thesis on the basis of their work at Argonne and receive an M.S. in chemical engineering at Oklahoma A. & M. with a nuclear engineering option.

Dr. Robert B. Mesrobian was promoted to Professor of Polymer Chemistry at the **Polytechnic Institute of Brooklyn.** He was also named Assistant Director of the Polytechnic's Institute of Polymer Research.

Lamme Award—1955—Vannevar Bush



To VANNEVAR BUSH *for his work on operational methods of circuit analysis, on electrical computing machines, and on servo-mechanisms, which pioneered the introduction of these several subjects into engineering education, and also in recognition of his leadership in developing the pattern for government support of research in universities that has had such a profound effect on engineering education in the last decade, we award this twenty-eighth Lamme Award.*

VANNEVAR BUSH, electrical engineer, executive, was born at Everett, Mass., March 11, 1890, son of Richard Perry and Emma Linwood (Paine) Bush. His father was a Universalist clergyman.

Dr. Bush was graduated from Tufts College with the degree of B.S. and M.S. in 1913 and later took graduate work at Harvard and the Massachusetts Institute of Technology, both of which awarded him the D. Eng. degree in 1916.

He was with the test department of the General Electric Co. in 1913 and the inspection department of the U. S. Navy in 1914, instructor in mathematics at Tufts College in 1914–15, and assistant professor of electrical engineering there in 1916–17. While the United States was engaged in the First World War he carried on re-

search work in connection with submarine detection for a special board of the U. S. Navy. In 1919 he returned to the Massachusetts Institute of Technology as associate professor of electric power transmission and was made professor in 1923, becoming Vice President of the Institute and Dean of its school of engineering in 1932. He held these positions until 1938 when he was elected president of the Carnegie Institution of Washington, D. C.

In 1940, while still retaining his position with the Carnegie Institution, he was appointed by the President of the United States as Chairman of the National Defense Research Committee. A year later Dr. Bush was made Director of the newly established Office of Scientific Research and Development charged with the duty of mobilizing the scientific effort of the country. He continued in this post until the OSRD was terminated in December, 1947.

As chairman of the NDRC and later as Director of OSRD, Dr. Bush was a central figure in the development of nuclear fission, which culminated in the use of atomic bombs to bring the war to an end. His official connection with the project began in June, 1940, when the earlier constituted Uranium Committee was made a subcommittee of the newly created NDRC. As a member of the Top Policy Group headed by the President and as chairman of the Military Policy Committee, he shared responsibility for the determination of policy throughout the program, continuing in this work after the task of administration and development had been taken over by the Army in 1943.

President Roosevelt in the fall of 1944 called on Dr. Bush for recommendations on ways whereby the lessons learned through the OSRD in time of war might be applied in time of peace "for the improvement of the national health, the creation of new enterprises bringing new jobs, and the betterment of the national standard of living." In response to this request, Dr. Bush prepared a report, issued in July, 1945, under the title "Science, the Endless Frontier," which drew on studies made by four committees of eminent scientists, engineers, and educators, and made specific proposals for the consolidation and utilization of the scientific skill of the nation for the general good. In July, 1946, Dr. Bush was appointed Chairman of the Joint Research and Development Board of the War and Navy Departments to carry out "a strong, unified, integrated, and complete research and development program in the field of national defense." The National Security Act of 1947 replaced the JRDB with the Research and Development Board of the National Military Establishment; Dr. Bush served from September, 1947, to October 15, 1948, as the first chairman of this organization.

Dr. Bush has received patents on gaseous-conduction devices and on cathode arrangements and coatings for grid-controlled arcs. His inventive interests have for years been focused on the application of mechanical and electronic means to reducing the burden of computation, calculation, and repetitive routine on man's intelligence. One expression of this desire is the network analyzer which, with staff members of the Department of Electrical Engineering, he developed at the Massachusetts Institute of Technology in the late 1920's.

Another and more important result of Dr. Bush's interest in this direction is the differential analyzer, construction of which began under his direction at the Massachusetts Institute of Technology in 1935, and which is a radically different and improved advance over the first machine of the sort, which he developed there in collaboration with the electrical engineering staff in 1930. The new machine, weighing 100 tons, combined some 2,000 electronic tubes, several thousand relays, about 150 motors, and nearly 200 miles of wire to provide solutions of the differential equations expressing mathematical problems involving as many as 18 variables. Problems in atomic physics, acous-

ties, ballistics, structures, and electrical machine transients are representative of the tasks for which the analyzer is designed.

Other devices such as the rapid selector which scans and selects wanted items from microfilm, and the justifying typewriter which produces typescript with an even right-hand margin in one operation, have resulted from Dr. Bush's inventive interest in making machines do more of the pseudo-intelligent work of the world. In the *Atlantic Monthly* for July, 1945, he wrote speculatively and fancifully of a hypothetical machine called the "memex," which, utilizing components of this sort, would serve as an extension of man's memory, bringing wanted items before him on a viewing screen by means of an associative index, and permitting him to review at the touch of a finger all his accumulation of data on a desired subject. Dr. Bush's independent research work on the justifying typewriter helped in the develpment of a photographic type composing machine called the "Photon," which uses a photo-electric process rather than movable type for printing.

Dr. Bush is the author of "Operational Circuit Analysis" (1929) and many technical articles, and the co-author, with William Henry Timbie, of "Principles of Electrical Engineering" (1922). A collection of his papers and addresses was issued in 1946, under the title "Endless Horizons." His most widely known publication is "Modern Arms and Free Men," a discussion of the role of science in preserving democratic institutions.

Dr. Bush holds honorary degrees from 19 universities and colleges, has been presented with a number of medals and awards for his achievements, and has been elected to honorary membership in many distinguished learned societies. He was married to Phoebe Davis of Chelsea, Massachusetts on September 5, 1916, and has two sons, Richard Davis Bush and John Hathaway Bush.

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To ROBERT ROY WHITE *for his inspiring efforts in the interests of better teaching; for his ability to develop new ways of presenting engineering principles; for his capacity to stimulate students and his associates; for his extension of engineering teaching to practicing engineers; for the presentation of his research before technical meetings; for significant publications in several areas of endeavor; for contributions to the administration of graduate and undergraduate programs; for devotion to the development of the capacity of young engineers, we award this tenth George Westinghouse Award.*

ROBERT ROY WHITE was born in Brooklyn, New York, on March 1, 1916. He received a B.S. degree in Chemical Engineering from the Cooper Union Institute of Technology in 1936. After a year of night school work at the Polytechnic Institute of Brooklyn, 1936–37, he enrolled in the University of Michigan, receiving the M.S. degree in Chemical Engineering in 1938 and the Ph.D. degree in 1941. He also attended the DePaul Law School at night in Chicago, 1941–42.

His industrial experience includes employment with the Calco Chemical Company, Dow Chemical Company, Standard

Oil Company of California, and Universal Oil Products Company. He is a registered engineer in the State of Michigan and engages in active consulting work in the field of distillation, reaction kinetics, and transfer operations.

He initiated his teaching career as an Instructor at the University of Michigan in 1942, reaching the status of Professor in 1950. His promise as a young teacher was recognized by the University of Michigan, in 1946, through the Russell Award.

During his teaching career he has taught courses covering practically all of the material which one finds in the modern undergraduate curriculum in Chemical Engineering. He has been active in modernizing the undergraduate work and in developing several new graduate courses in chemical engineering. These embrace material in rate processes, reaction kinetics, azeotropic and extractive distillation, and separation operations. He is an active contributor to the curriculum committee of the Engineering College, as well as a member of the Executive Boards of the Horace H. Rackham School of Graduate Studies and of the Extension Division. He has been chairman of the committee which originated the Nuclear Engineering program of the Engineering College and is currently chairman of the committee which has developed the new Science Engineering program.

Professor White has long been active in research. His publications number about sixty to date. In 1946 he received the Junior Award of the American Institute of Chemical Engineers for his contributions to Chemical Engineering literature.

He married Elizabeth Clark of Niagara Falls, New York, on July 2, 1940. They have four children, Robert, William, Elizabeth and Margaret, age thirteen, nine, four, and two, respectively.

Professor White's honorary and professional associations include ACS, AIChE, ASEE, AAUP, AGA, MGA, AAAS, Phi Kappa Phi, Alpha Chi Sigma, Tau Beta Pi, and the Michigan Society of Professional Engineers.

ATTENTION

If anyone has the following issues of the JOURNAL OF ENGINEERING EDUCATION, please contact Marshall Lebowitz of J. S. Canner & Co., 46 Millmont St., Boston 19, Mass. *directly.*

JOURNAL OF ENGINEERING EDUCATION:

Volumes 1, nos. 1–3, 8–10; 5, nos. 7, 9; 6, nos. 2–7; 7, nos. 6–8; 8, nos. 7, 8; 9, nos. 2, 4–6, 9; 10, nos. 4, 9; 12, nos. 3–10; 13, nos. 1–6, 9; 14, nos. 2, 7.

Candid Comments

By JOHN E. DEAN

Head, Dept. of Electrical Engineering, Colorado A. & M. College

The two articles, "Evaluating Good Teaching" by R. D. Stout and "Evaluation of Engineering Teaching Ability" by T. H. Evans plus your invitation for comments in the May issue of the JOURNAL, "stir me to take pen in hand." As Stout and Evans so ably point out it is difficult for an administrator to determine the calibre of teaching of members of his staff. Both authors agree that a good teacher should "stimulate the student in independent thinking" and "get the subject across." Indirect methods of measuring are suggested, as professional activity and publication.

Now, since we are dealing with a complex problem involving human behavior, why not try a simple approach? The Bible tells us that "where thy treasure is so will your heart be also", and "as a man thinketh so is he." Let us take the hypothetical engineering teacher X and, in an unguarded moment, ask him, "What's new?" If the psychological stage has been properly set, X's reply should reveal where his treasure is and of what he thinks. My experience has elicited discussions of the Dodger's pennant chances, the bonehead substitution by the football coach in last Saturday's game, or a behind the hand narration of the latest campus gossip. However, the response we are seeking is a lively narration of success or failure in a bit of research, the latest thought on Unity in the Profession or a new way of presenting a fundamental law to students.

Now the above procedure is sneaky, unethical and strictly beneath the professional dignity of an educator. (Why don't you try it on a colleague sometime?) However, let us be serious for a moment. Have you ever, when the last paper is graded and the family long since in bed and asleep, pondered the problem of how to get across the concept of entropy or power factor to that thick headed —— in the last row? Or have you ever been struck by the idea of a classroom demonstration that is of the essence? Be honest with yourself—do you enjoy teaching, your contacts with students and their problems in the classroom and out? Do you feel that training young men and women to practice in the field of engineering is more important than practicing yourself, in spite of the financial rewards the latter can bring? By your answers you shall know whether or not you are a good teacher and that is what matters.

THE T-SQUARE PAGE

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Descriptive Geometry Helps the Surveying Instructor

By ROBERT P. VREELAND

Assistant Professor of Civil Engineering, Yale University

Because of the reduction of time devoted to surveying courses and the elimination of spherical trigonometry from most Civil Engineering curricula, the necessary background for understanding methods of azimuth determination must

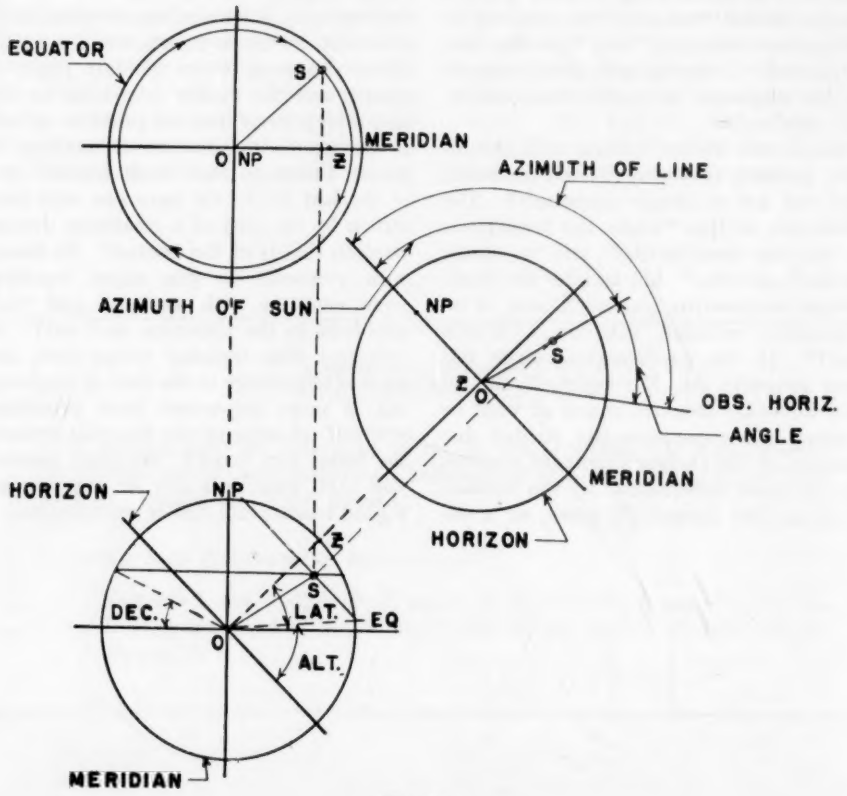

FIG. 1.

be provided in the most efficient manner possible. We have found that the approach by means of Descriptive Geometry has enabled the students to grasp readily the basic relationships between the angles in the astronomical triangle.

The problem (illustrated in Figure 1) is to determine the azimuth of a survey line (the clockwise angle the line makes with true north). The field procedure in brief is to measure the horizontal angle between the sun and the line and the vertical angle (altitude) between the horizon and the sun. Assumed known are the declination (angle between the equator and the sun) and the latitude (angle between the equator and the observer or between the horizon and the north pole). In Figure 1, then, the latitude locates in the plane of the observer's meridian, the observer's horizon and zenith with respect to the equator and pole. The declination locates the sun's path for the day with respect to the equator. Then the altitude locates the sun on its daily path. This position of the sun may then be projected onto the equator view and finally transferred to the horizon view thereby determining the azimuth of the sun. This angle is then added to (or subtracted from) the observed horizontal angle to obtain the azimuth of the line.

If Polaris (the North Star) is used instead of the sun for azimuth determination, the star's position on its daily path cannot be located sufficiently accurately by its altitude since this quantity varies only a few degrees during the course of a day. It is therefore located in the plane of the equator by its Greenwich Hour Angle (the angle between the Greenwich meridian and the star). This angle is known if the time of the observation is noted. The star is then projected from the equator view into the meridian view and finally into the horizon view as before.

It is possible of course to derive by plane trigonometry relationships between these angles. However the principal value of this method would seem to lie in its simplicity and in the use of a subject with which the engineering student is familiar.

Lisle Abbott Rose

Dr. Lisle Abbott Rose had been selected to become Editor of the JOURNAL OF ENGINEERING EDUCATION on July 1, 1955. But on the evening of May 23 Lisle had a sudden heart attack which almost immediately proved to be fatal. The death of Lisle is a great loss to the Society and to the College of Engineering of the University of Illinois. His boundless energy, enthusiasm, clear thinking, and gracious good humor will be missed.

Lisle wasn't an engineer, but through his long association with engineers and technical editing, both at the University of Illinois and Michigan College of Mining and Technology, he knew engineering education and its problems. His interest in ASEE was deep and continuous. He was a long-time member of the English Division and was serving as its vice-chairman at the time of his death. Other recent ASEE activities were chairman of the Public Relations Committee, co-author with Professor John C. Reed of the University of Florida of the new Guide for Annual Meetings, and Chairman of the Local Annual Meeting Committee at the University of Illinois in 1954. Lisle had many plans for the future and the Executive Board and General Council were looking forward to vigorous and stimulating results.

To Mrs. Rose and their two sons, the Society extends its most sincere sympathy. May the simplicity of this expression represent the depth of our feelings.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, University of Illinois, Urbana, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR IN CIVIL ENGINEERING to teach general engineering science and civil engineering subjects. Master's degree preferred. Salary for nine months. Department of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo.

ENGINEERING FACULTY OPPORTUnities at Mid-Western Technological College. Rank of Instructor or Assistant Professor and salary commensurate with qualifications. Industrial experience in a related field and/or teaching experience desirable but not prerequisite. Electrical Engineering. Ph.D. or M.S. with major interest in electronics. Electrical Engineering. M.S. degree with major interest in power. Mechanical Engineering. Graduate studies in progress essention. Attained Masters desirable. Mining engineering. Masters degree or work toward it desirable. SEP–2

AERODYNAMICS OR FLUID MECHANics position open for undergraduate and graduate teaching. Desires man who either is, or will be, an outstanding teacher for both undergraduate or graduate courses. Man must have proven ability for research and publication. Subsonic and supersonic research facilities available. Advanced degree required. Rank and salary open. Please forward complete details of education, experience and personal background to Chairman, Department of Aeronautical Engineering, University of Detroit, Detroit 21, Michigan.

RESEARCH ENGINEER IN FLUID MEchanics. Ph.D. preferred but would consider man with M.S. if well qualified. Person applying should be thoroughly competent in the associated mathematics and also should be able to assume project leadership. Department of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo.

FLUID MECHANICS ENGINEER WITH knowledge of micrometeorology and boundary layer phenomenon to study wind tunnel modeling of micrometeorology. Will assume project leadership responsibilty. Department of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo.

RESEARCH ENGINEER IN FLUID MEchanics for work in open channel flow. Ph.D. or M.S. desired. Person who can take leadership responsibility is desired. Salary depending on qualification. Department of Civil Engineering, Colorado A. & M. College, Fort Collins, Colo.

INSTRUCTORS AND ASSISTANT PROfessors in Surveying, Engineering Mechanics, and Fluid Mechanics, wanted by University in Southeast. Instructors with B.S. will have opportunity to work for M.S. while receiving full compensation. Salary commensurate with education and experience. Positions start September 1955. SEP–1

New Members

AMMERMAN, CHARLES ROYDEN, Associate Professor of Electrical Engineering, Pennsylvania State University, University Park, Pa. C. B. Holton, R. E. Armington.

ARADER, HARRY F., Lecturer, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia 4, Pa. Reid Warren, J. B. Brainerd.

AUSTIN, WALTER JAMES, Research Associate Professor, Civil Engineering Department, University of Illinois, Urbana, Ill. Clyde E. Kesler, W. M. Lansford.

BACON, WILLIAM E., Technician Recruiting Engineering Personnel, General Electric Company, Schenectady, N. Y. V. E. Neilly, Harold Hecklin.

BARKER, HARRY, Consulting Engineer, Barker and Wheeler Engineers, New York, N. Y. N. A. Parker, G. A. Rietz.

BARTLESON, EDWARD E., Staff Assistant Personnel Relations, American Telephone and Telegraph Co., New York, N. Y. Donald A. Bridgman, Russel A. Deller.

BASSETT, DAY L., Assistant Agricultural Engineer, State College of Washington, Pullman, Wash. Max C. Jensen, June Roberts.

BAULING, FREDERICK G., Research Associate, Theoretical and Applied Mechanics Department, University of Illinois, Urbana, Ill. H. J. Schrader, W. Leighton Collins.

BEDWELL, THOMAS H., Head of Mathematics Department and Supervisor Electrical Trades, Southern State Teachers College, Springfield, S. Dak. H. M. Crothers, William H. Gamble.

CASE, EUGENE HOWARD, Director of College and University Relations, Deere & Company, Moline, Ill. Lee L. Amidon, Emory E. Johnson.

CLARKE, RICHARD GUTHRIE, Chairman of Engineering Division, Hillyer College, Hartford, Conn. Paul M. Pepper, Harry L. Beach.

CONTINI, RENATO, Research Coordinator, New York University College of Engineering, New York University, N. Y. Harold Toyersen, Harold K. Work.

DAVIDSON, RAYMOND ALONZO, Instructor in Electrical Engineering, University of Utah, Salt Lake City, Utah. M. E. Van Valksenburg, Philip Weinberg.

DECICCO, MICHAEL A., Assistant Professor of Mechanical Engineering, University of Notre Dame, Notre Dame, Ind. W. W. Turner, Hugh P. Ackert.

EDINGTON, WILLIAM F., Head of Psychology Section, English and Psychology Department, General Motors Institute, Flint, Mich. C. A. Brown, Harold M. Dent.

FROSSI, PAOLO E., Electrical Engineer, Societta Edison, Milano, Italy. W. R. Woolrich, W. Leighton Collins.

GOETZ, BILLY E., Professor of Industrial Management, Massachusetts Institute of Technology, Cambridge, Mass. Arthur Lesser, Jr., Eugene Hunt.

GOLDBERG, MAXWELL H., Professor of English, South College, University of Massachusetts, Amherst, Mass. Lisle A. Rose, W. L. Everitt.

GUILLOU, JOHN C., Research Assistant Professor, Civil Engineering, University of Illinois, Urbana, Ill. Jess C. Dietz, Thomas C. Shedd.

HALL, WILLIAM J., Research Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. N. M. Newmark, W. Leighton Collins.

HARRIS, LUCIUS JOHN, Assistant to Manager, Industrial Relations Division, E. I. du Pont de Nemours, Inc., Wilmington, Del. B. M. Taylor, Ralph A. Emerson.

HARRIS, ORVILLE RALPH, Associate Professor of Electrical Engineering, University of Virginia, Charlottesville, Va. L. R. Quarles, J. L. Vaughan.

HAUF, HAROLD D., Chairman of Architectural Group, Rensselaer Polytechnic Institute, Troy, N. Y. P. E. Sorreson, P. E. Hemke.

HECKELMAN, RICHARD W., Instructor in Electrical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitola, Russell C. Putnam.

HERTIG, BRUCE ALLERTON, Instructor in Technical Department, Sinclair College, Dayton, Ohio. Herbert F. Marco, Harold B. Kepler.

HOKE, WALTER M., Instructor in General Engineering, University of Washington, Seattle, Wash. Herbert Boehmer, Clarence E. Douglas.

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INCE, SIMON, Assistant Professor of Civil Engineering, Rutgers University, New Brunswick, N. J. W. B. Snow, Anthony J. DeMastro.

KRAUS, JOHN W., Section Supervisor, Quality Control, Thompson Products, Inc., Cleveland 17, Ohio. N. A. Parker, C. J. Carney, Jr.

LAFEBER, THEODORE J., President of DeVry Technical Institute, Chicago, Ill. O. J. Thompson, Joseph J. Gushon.

MARLOWE, DONALD E., Dean of School of Engineering and Architecture, Catholic University of America, Washington, D. C. Thomas J. Killian, Frank A. Biberstein.

MEDFORD, WILLIAM E., Coordinator of College Relations—Personnel, Western Electric Co., New York, N. Y. Maurice D. Quinlan, Donald S. Bridgman.

MURPHY, J. EDWARD, General Personnel Supervisor—Executive Personnel, The Bell Telephone Company of Pennsylvania, Philadelphia, Pa. Donald S. Bridgman, Russell A. Deller.

OEHMANN, JOHN CARLTON, Assistant Professor of Civil Engineering, Catholic University, Washington, D. C. Frank A. Biberstein, Louis E. Cattaneo.

ORLOB, GERALD T., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. E. P. Popov, Karl S. Pister.

OXFORD, CARL J., JR., Research Engineer, National Twist Drill and Tool Company, Rochester, Mich. Orlan W. Boston, Robert E. McKee.

PEARSON, ROBERT H., Assistant Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. Ronald V. Giles, John L. Rumpf.

POUCHER, MELLOR P., Instructor in Engineering Science, University of Western Ontario, London, Ontario, Canada. L. S. Lauchland, W. S. Wilson.

RAYFIELD, JAMES H., JR., Director of Evening Division, Adelphi College, Garden City, New York. Harold Forgersen, A. H. Church.

RICH, JOSEPH A., JR., Associate Professor of Management Engineering, Newark College of Engineering, Newark, N. J. Oliver J. Sizelove, W. J. Jaffe.

RICHARDS, WILLIAM L., Instructor—General Extension, College of Engineering and Architecture, Pennsylvania State University, University Park, Pa. Kenneth Hunter, V. E. Neilly.

RIEDESEL, GERHARD A., Research Engineer, Division of Industrial Research, State College of Washington, Pullman, Wash. James H. McFerron, Roger H. Nelson.

SEGNER, EDMUND PETER, JR., Instructor in Civil Engineering, Texas A. & M. College, College Station, Texas. R. L. Peurifoy, S. R. Wright.

SIESS, CHESTER P., Research Associate Professor, Civil Engineering Department, University of Illinois, Urbana, Ill. Clyde E. Kesler, W. Leighton Collins.

STALLMEYER, JAMES E., Research Assistant Professor, Civil Engineering Department, University of Illinois, Urbana, Ill. N. M. Newmark, W. Leighton Collins.

STANEK, FLOYD J., Instructor in Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. Omar M. Sidebottom, W. Leighton Collins.

STEELE, MONTGOMERIE C., Research Associate Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. J. O. Smith, W. Leighton Collins.

TORNQUIST, THOMAS E., Editor, Engineering Department, The Ronald Press, 15 East 26th Street, New York City, N. Y. George W. Farnham, W. Leighton Collins.

VANDREY, COLVIN, Assistant Professor of Civil Engineering, South Dakota State College, Brookings, S. Dak. Emory E. Johnson, Wm. H. Gamble.

VON KAENEL, JOHN C., Instructor in Drawing Design, Clemson A. & M. College, Clemson, South Carolina. James H. Sams, Joseph E. Shigley.

WAIBLER, PAUL J., Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash. James B. Morrison, Morris E. Childs.

WILSON, ROBERT E., Head of Chemical Engigineering Department, University of Dayton, Dayton, Ohio. Shao-Ti Hsu, Andrew R. Weber.

WOLFE, HUGH C., Professor of Physics and Head of Physics Department, The Cooper Union School of Engineering, New York 3, N. Y. Norman L. Towle, Frederic H. Miller.

YUSTER, SAMUEL T., Professor of Engineering, University of California at Los Angeles, Cal. Wesley L. Orr, C. Martin Duke.

54 new members this list

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute of Technology	April, 1956	J. W. Graham, Jr., Carnegie Institute of Technology
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	R. M. Kerchner, Kansas State College
Michigan	Wayne University	May 6, 1956	G. H. Howell, Wayne University
*Middle Atlantic	New York University		C. C. Carr, Pratt Institute
Missouri-Arkansas	St. Louis University	April 7, 1956	J. B. Macelwane, St. Louis University
National Capital Area	Capital Radio Engineering Institute	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	University of Maine	Oct. 8, 1955	E. R. McKee, University of Vermont
North Midwest	South Dakota State College	Nov. 4–5, 1955	L. L. Amidon, South Dakota State College
Ohio	Ohio State University	April 28, 1956	E. C. Clark, Ohio State University
*Pacific Northwest			J. B. Morrison, University of Washington
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1955	R. G. Moses, Pasadena City College
*Rocky Mountain	Denver University		W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 14–15, 1955	B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No Date Set.

Do You Know—

► One of the aims of your Editor and Secretary for the coming year is to get each issue of the JOURNAL to you during the month of issue. Perhaps we shouldn't "stick our necks out," but we want you to know we are going to try. There will be some problems and some departures from custom may need to be made. That is particularly true of the *Yearbook,* the February issue. It is the chief cause of delay and the enrollment and degree statistics may have to be published in another issue. And in regard to the *Yearbook*—we get complaints about it not being up to date. But did you send in your change of address card promptly? The *Yearbook* can be only as good as the members make it.

► The Technical Institute Division is organizing its forces for a big job—a book on Technical Institutes and Technical Institute Education. The project is made possible by the generous gift of securities valued at about $6,000 by Arthur L. Williston, retired principal of Wentworth Institute. Mr. Williston, a member of the Society since 1897, was a vice president of the Society in 1909–10, Secretary in 1907–09, and a member of the General Council in 1900–03 and 1905–08. He is also the third recipient of the James H. McGraw Award, 1952. The Society is grateful to Mr. Williston for his generosity in making possible the preparation of a much needed book on Technical Institutes. The committee appointed to prepare the book consists of Professor H. P. Adams, F. E. Dobbs, M. R. Graney, S. C. Hollister, Miss J. Miller, B. T. Thorogood, and Mr. A. L. Williston.

► The program of the Annual Meeting of Engineers Joint Council is to be devoted to a discussion of technical institute education. ASEE and ECPD have been asked to cooperate in the planning; each organization will have two representatives on the planning committee. The nature and scope of technical institute training and the relation between such graduates and engineering graduates in an attempt to meet our engineering manpower needs is the central thought of the meeting. Representatives from industry and the armed forces will be invited to participate in this discussion of the effective use of engineering technicians.

► The Committee on Evaluation of Engineering Education has been discharged. It has done a monumental task and is to be highly commended for its work. To its chairman, Dean L. E. Grinter of the University of Florida, to its secretary, Professor D. H. Pletta of Virginia Polytechnic Institute, and to each member of the committee, the Society owes a deep debt of gratitude and appreciation. A pattern has been developed for the future and our sights now can be focused on objectives. The next step is implementation, and to be sure something is done it is proposed that a new committee be appointed, its membership composed of the chairmen of Divisions. The committee will work out its own plans and procedures.

► The Teaching Aids Bulletin committee also has been discharged. With the publication of the *Educational Aids Manual* the work of the committee has come to a close. The project, however, should not be thought of as dead; there are additional areas of engineering to be covered and funds are available for the work if the need exists and the interest is evident. Carl W. Muhlenbruch of Education and Technical Consultants, Inc., spent a tremendous amount of work on this project; he and all who worked with him are thanked for their efforts. The Manual has been a success; the first printing is almost exhausted and plans are being made for reprinting.

► The third ad hoc committee to be discharged is Printing Economy, G. W. Farnham, Chairman. A committee by such, or similar, name is appointed about

every five years to study the cost of printing the JOURNAL OF ENGINEERING EDUCATION. In its latest study, it reported the prices charged by Lancaster Press were reasonable and that they were giving excellent service. A few odds and ends remain to be checked, but our Treasurer, G. W. Farnham, has been asked to report directly to the Executive Board.

► *"Aim for Ames in '56"* will be seen and heard many times during the coming year. It will be the phrase most frequently used in the publicity for next year's Annual Meeting at Iowa State, June 25–29. Mark the date on your calendar and *"Aim for Ames in '56."*

► The YET Committee has agreed to conduct an active membership drive as part of its program for the coming year. They have done a good job in the past and will do so again. It is hoped every institution will have an active YET group working on membership. Comments received at the Annual Meeting indicate that some schools are planning their own campaigns for all members of the faculties; some said each of us should do more as individuals. Anyone wanting application blanks can get them from the Secretary's office. The *Yearbook* always contains a membership application form, but for everyone's convenience, now that a new school year has just started, an application blank is printed below. Give it to a friend, have him fill it out and mail it to the Secretary's office.

W. Leighton Collins,
Secretary.

Return to the Secretary, W. Leighton Collins, University of Illinois, Urbana, Ill.

Date.....

I desire to become a member of

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

and hereby agree to conform to the requirements of membership, if elected, and submit the following

STATEMENT OF QUALIFICATIONS

Name and Surname..... (Print Last Name) (First) (Middle)

Mailing Address..... (Number and Street)

Post Office..... (City, Postal Zone and State)

Title of Professional Position..... (Title) (Department)

Name of Institution.....

Academic Degrees.....*Institutions*.....

.....

Annual dues are $8.00 per year except from members under 36 years of age whose dues are $6.00 per year. The Society's fiscal year starts July 1. If you are under 36 years of age on July 1, please give your date of birth .....

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.....

(To be signed by two Sponsors, Members of A.S.E.E.)

An Administrator Takes a Look at General Studies for Engineers

By JESS H. DAVIS

President, Stevens Institute of Technology

As far as I can tell, the excitement about teaching the humanities and social studies in engineering colleges broke out sometime in the 1920's. I'm not sure why it all started just then, unless it was that during World War I, American industry made its influence felt on a grand scale for the first time. And American industry was built, in large part, by engineers. Apparently, someone decided right then and there that engineers might become rather important people in our society one day and that they ought to try to pull themselves above the vocational category in which many people placed them—and with some justification as we all know.

Engineers were painted by some as noisy louts with dirty fingernails who never had anything to talk about at faculty teas except nuts and bolts. It was said that they didn't know how to express themselves, they had no knowledge of art or history, of literature or economics and couldn't even conjugate a Latin verb. Someone decided that, if these men were to become important in the scheme of things, they would just have to acquire some "culture." It never *was* explained just what was meant by "culture," but before anyone knew it, the panic was on.

After some sage head-waggings on the part of deans and presidents, engineering schools that didn't already have them, started installing courses, even programs in the humanities. "Culture for Engineers" became the by-word and before long the bright young man whose only ambition was to build a bridge or design a dynamo was trying to use his integral calculus to decipher the writing of someone named Geoffrey Chaucer.

Today, after the passage of some thirty or thirty-five years, you can attend faculty teas—or literary cocktail parties—and *still* hear people talking about engineers. And what they are saying is: "Engineers can't express themselves adequately, they don't appreciate art, history, literature or economics and they *still* can't conjugate Latin verbs."

Well—maybe these critics are right. But a new sound is being heard these days. When engineers get together—with their nails now carefully cleaned—they are starting to make many of the same comments about some of the graduates of our liberal arts colleges. They go one step further and point out that when it comes to clear, logical and independent thinking, too many of the liberal arts graduates are —to use the elegant phrasing of an English literature major in a Madison Avenue advertising agency—"out in left field with prunes in their mouths."

Now, I think the social-humanistic programs in most of our engineering colleges —including my own—leave much to be desired. In some instances, I think this probably stems from the fact that too many engineering administrators were anxious—back in the twenties and thirties —to get on the "Culture for Engineers" bandwagon. And they did it without thinking through what they hoped to ac-

* Presented at the Annual Dinner of the English and Humanistic-Social Divisions, ASEE, Penn State University, June 20, 1955.

complish or whether what they were doing was going to accomplish it. In fact, I'm not sure but what most of us are still a little fuzzy about objectives.

Objectives

No one can quarrel with the objectives set out by the several committees of this society and others regarding the social-humanistic stem. But, I wonder whether those objectives aren't too general and too broad in scope for us to even hope to realize. Certainly they are too general and unwieldy ever to admit of measuring results. Now I am fully aware that the values we hope to impart through the teaching of literature and history and philosophy and art and music are not measurable in the cold mathematical sense. But I do believe that we can arrange our courses of teaching in such a manner as to provide a continuing comparison of achievements with previously stated goals.

We set forth as the objectives of the humanities program such things as these: "to foster an understanding of the forces that have shaped modern society and to develop an appreciation of great achievements in literature, philosophy and the arts so that students may become alert and informed men, able to recognize true values and place engineering in its proper relation to other human endeavors." Now, I agree that that is a fine statement, carefully shaped after solemn declarations of objectives by this society. In fact, it had better be a good statement—it comes from the current Stevens Catalog.

But, as I said at the outset, I am confused. One reason is that as an administrator who is supposed to keep an eye on the big, broad picture, I have no way of determining whether we are within several city blocks of the goals described in that statement.

I am perplexed by such words as "understanding"—"to foster an understanding of the forces that have shaped modern society." What kind of understanding—how deep, how broad, how extensive? Just how much understanding of such vaguely defined objectives can you humanly expect a student to absorb during twenty or twenty-five semester hours of study per week spread out over four years?

Again, what are "true values"? I confess I don't know. Of course, I'm an engineering school graduate myself and didn't have time to delve too deeply into the conflicting interpretations of this term by the various philosophers and poets. But maturity and experience and observation should be worth something, and yet I'm sure I couldn't give you a definition of "true values" that would satisfy more than ten per cent of the people in this room. Yes, you may say, "Of course, there's no real, universal definition of 'true values,' but we all know what it means." And I say to that, "That's a pretty sad way for an engineer to talk."

What I'm driving at is this: The sequence of mathematics and science and engineering courses each engineering college offers has a definite objective in mind. In very general terms it is to give a young man a certain amount of knowledge in the productive use of nature's forces and materials. This objective is predicated on what we believe are the requirements for a background upon which the graduate can build a broader or deeper knowledge of science and engineering as he pursues his activities in one or both of these areas. When the young man has met the requirements of the courses within the sequence he has automatically achieved the technical objectives of his college course and he satisfies, at least to a degree, his own desires and those of the industry in which he will be employed. Now, what I'd like to ask is this: "Can't we pursue this same method in the social-humanistic area? Can't we sharpen up objectives, then shape a program that will permit us to determine, with some assurance, how close we come to meeting those objectives?"

I think such a move would be desirable if only because it might prevent us from

spreading ourselves too thin in an effort to cover the same ground the liberal arts colleges, but in a third or a quarter of the time.

It seems to me that part of our difficulty arises from the fact that, in the beginning, we attempted to boil down the non-scientific content of the liberal arts curriculum into capsulized form so it would fit into such holes as were left in the engineering curriculum by cutting down the number of courses in subjects like machine and woodworking shop, forge, foundry and mechanical drawing. (Thus, we launched a two-pronged attack on the problem of the engineer's dirty fingernails.)

Fresh Look

But isn't it time we took a fresh look at things to see whether we, who know engineering students, can't come up with a new concept that will come closer to meeting their needs? Suppose we set aside the liberal arts tradition and attempt to create one of our own—a techno-humanistic tradition that recognizes and welcomes the influence of science and technology on our times and that attempts to learn from the best of man's past and contemporary achievements how to make the wisest use of the new forces now at our command. And let's attempt to do this in a manner consistent with the methods by which we so successfully teach science and engineering.

What I am about to suggest may not seem new or bright or fresh to many of you—particularly to those of you who are teaching the humanities. Perhaps you have tried to work out similar plans and you may have very real reasons for knowing why these proposals will not work. But I can tell you that as an administrator, I for one would be happier with *some* new approach simply because it would ease my mind that we were doing something I could describe in fairly concrete terms to a board of trustees or a prospective benefactor.

The first step in establishing a new techno-humanistic stem would be to set up very firm objectives that would get down to specifics. These would be molded out of the statements of broader objectives agreed to by such groups as this one. But each objective would be divided into smaller, definable elements, and courses would be shaped to meet the requirements indicated by each. I am not going to attempt a breakdown for you because each college should make its own. Instead, I would like to ask you to examine with me, the general objectives of the social-humanistic stem as set forth in the Report of the Committee on Engineering Education After the War, issued in 1945. It is rather appropriate that we examine into this thoughtful report at this time, since the chairman of that committee was Mr. H. P. Hammond, then Dean of Engineering at our host college.

A summary of the Hammond Committee's report appearing in the Society's journal sets down five desirable objectives for the humanistic-social stem. Let's look into one of those general objectives. Take the one that advocates "an appreciation of cultural interests lying outside the field of engineering." Here again we are faced with a problem in semantics—the word "appreciation" by itself does not indicate degree or amount, and "cultural" is a term which, as I have noted, defies measurement. I am glad, however, that the statement seems to make the field of engineering itself either a form of culture or a force which affects culture.

Individual Treatment

But let's assume that, like "true values," we *all know* what "culture" means and that it is inherent in the study of subjects like literature, art, music, the theater. Now to begin with, I don't believe that these subjects can be adequately covered in a catchall course that attempts to combine all four, along with, perhaps, a study of man's social and cultural development over the ages. It seems to me that, to avoid superficiality, each of these subjects should be given individual treatment. I'm fully aware that we can't

devote a full course to each. However, I *do* think that if we carefully select certain phases of each and treat those phases in some depth—within the time limitations of the total curriculum—we can approach something like "understanding" and, perhaps, whet the appetite for independent exploration of other phases.

The selection of the phases or portions of each field to be studied is, of course, all-important. I think you will agree that the purpose of exposing a student, in any kind of college program, to greater or lesser amounts of English literature, for example, is to help him to recognize certain values in good writing, and to make him want to continue to read and to enjoy worthwhile books. But in the selection of these books, I fear, we have pretty much followed the traditionalists—an unbecoming situation for a group which prides itself that its graduates are becoming *leaders* of vast influence.

Looking at it quite objectively, are we prepared to assert that the study of the Norse sagas, of Pope, and Dryden and Dante and Milton is the best way of getting engineering students, or too many other kinds of students, interested in reading? Aren't there other authors, with equally high literary standards, whose writings are much closer to the experience of the student and which he would read with greater enthusiasm and profit—and with longer-lasting effect?

Since the engineer created and is also a product of the Industrial Revolution, wouldn't it seem reasonable to have the engineering student concentrate on the literary products of that era? Instead of asking the student to get excited about the writers of the dim distant past, why not instead give him greater exposure to writers like Bernard Shaw and Sinclair Lewis and Scott Fitzgerald and Dreiser and Hemingway and Aldous Huxley? These are men with high literary standards who have written of an era in which the student is far more at home than he is in Boswell's age. Isn't he likely to respond to them more readily—and isn't he more likely to develop the habit of reading and perhaps, in pursuance thereof, one day look up some of the older authors? Isn't this better than actually discouraging him from reading by asking him to grapple with respectable, but what he considers rather dull writers?

And why continue to make a fetish of reading Shakespeare? Since Shakespeare wrote for the theater, why not encourage students to see his plays in the theater—or in the movies? If you do, you might even find an occasional student who will read a play before seeing it on the stage or screen and one or two who might be encouraged to read another afterwards.

Speaking of plays and playwrights, isn't a student likely to take more interest in the theater if he is introduced to it by way of Shaw and Eugene O'Neill and Robert Sherwood and Sidney Howard and Elmer Rice and Sidney Kingsley than by way of Aeschylus and Euripides and Aristophanes?

The same reasoning applies to the teaching of music. Now, I'm not an afficionado of jazz, but jazz and popular music in general are a lot closer to the average student than Bach or Mozart. It seems to me that a skilled teacher shouldn't have too much difficulty in pointing out certain values in popular music that reflect those found in the work of the masters. By listening to Beethoven and Haydn in illustration of these points, the student might give willing attention to something he has before arbitrarily dismissed as "long-hair."

The study of art ought to be a relatively popular one in an engineering college, I think. I know that I have seen a good deal of painting and sculpture done by engineering students, and some of it has been quite acceptable. Why, then, don't we encourage more students to get their hands on an artist's brush or a piece of modeling clay—many of them are good with their hands and would enjoy the opportunity. If they become sufficiently

interested, they probably would *demand* more knowledge about the whole field of art. This, to my mind, is far better educational procedure than compelling students to drag themselves unwillingly through an art gallery, or to read a dry book about art.

Component Parts

Do I make clear what I have in mind? First, take the general objective and break it down into component parts. In this case, "cultural interests" can be divided into four major parts: literature, theater, art, music. You might not agree with my arbitrary sub-divisions, but whatever ones you select, I think you ought to concentrate on limited areas of each. And in selecting those areas, I think you will be wise to select those which are closest to the experience and interest of the students. I am satisfied that diligent searching will reveal them to you. As for areas more remote from the student's interests, I think some non-conformist thinking will uncover routes that will lead the student enthusiastically to them and that proper exposure will assure his continuing, self-sustaining interest.

But, above all, if you want to teach a subject—teach it. If it be the art of stamp collecting—give a course in stamp collecting. Don't rely on the student himself to get the hang of it by synthesizing the overflow from courses in paper-manufacturing, engraving, adhesives, and an interpretation of the U. S. Postal Regulations.

For another illustration, let us return to the Hammond Report. A second of its stated objectives is "acquaintanceship with the enduring ideas . . . to serve as guides to ethical and moral values." Well, if we want to teach ethical and moral values, why don't we simply give a course in ethics? Why not study the major religious faiths and the moral precepts each advances—even trace their translation into the laws and customs that affect our daily lives? If a knowledge of ethics and morals is a desired objective, why leave it to chance and hope that it will be realized as a by-product of other courses?

If we approve of the report's objective of encouraging "the development of an adequate concept of the duties of citizenship in a democratic society," are we doing enough in a concrete way to attain that objective? Shouldn't most of us be teaching more about the organization and functioning of our federal and state governments, more about the bureaus and agencies that affect the lives of the students who are part of that "democratic society"? And shouldn't we be spelling out what the "duties of citizenship" are and how they may be performed?

If we agree with the report that another objective of the humanities curriculum is to "understand and analyze the essentials of an economic, social or humanistic situation" and to "relate it to the life and work of the engineer," are we doing enough to bring out the influence of technology on our society so the student can trace the relationship? I don't mean modern technology alone, but the influence of engineering ideas on the growth of cities, in satisfying the need for food and water, in seeking sufficient natural resources, in the development of methods of transportation and communication, and on the need for energy sources?

When we start enumerating the items that are implicit in the broad objectives stated by the Hammond Report, it becomes apparent that we are attempting to cover a lot of territory in a few semester hours. So, unless we are content to settle for a thin veneer of non-technical learning, we are going to have to take the engineering approach of singling out the more important objectives and creating a workable mechanism for attaining them.

Now, to reach even a limited number of objectives we shall have to insist on each student taking prescribed courses, rather than trusting to God and electives. In saying this, I realize I am going contrary to the present trend of integration and of survey courses. But I think it essential if we are really serious about

attaining the objectives we set for ourselves.

Functional Approach

I realize, also, that this approach is a purely functional one and that it will be held in high scorn by the purist in the arts tradition, to whom functionalism is anathema. These are what I call the educational non-objectivists. They offer a plethora of courses, seldom purposefully arranged to aid the student's mature development. As a result, many a student wanders through the Groves of Academe, plucking an attractive bloom here and another there until he emerges, at the end of four years, with a beautiful bouquet and no one to bestow it upon.

Most purists are inclined to sneer at science anyway because, they say, it is concerned only with verifiable truths and there are so many more important values which cannot be measured. This betrays a disturbing ignorance of the methods and philosophy of science. As we know, science has scored its greatest triumphs by postulating entirely unprovable explanations, then using these theories to soar into rarefied regions of thought seldom inhabited by philosopher or poet. If the end purpose of education is to excite and exercise the mind, then I submit that the average program in an engineering college does this a lot more effectively than most of the non-objective programs that I know about.

So, because of the effectiveness of our technical programs, I think we need feel no hesitancy in trying to plan a disciplined approach even to the non-engineering subjects—with objectives clearly staked out in such a manner that we can gauge the degree of our success in meeting them. But just let's be sure that we describe those goals in detail and that we have the determination not to be deterred from attaining them.

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This publication lists all of the schools in Canada and the United States which grant degrees in Chemical Engineering. Information is given concerning each school, such as accreditation by A. I. Ch. E. and E.C.P.D.; whether or not graduate work is given; number of degrees granted last year; the academic rank, name, and academic degree held by each member of the staff. An important item listed for company personnel men is the name of the college placement officer.

For What Types of Careers Should We Train Mathematicians?*

By RICHARD S. BURINGTON †

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For what types of careers should we train mathematicians? What sort of an attitude should color the philosophy underlying the training of mathematicians, especially at the graduate school level? And, how should these principles relate to advanced work in the engineering and physical sciences? It is to these questions that I direct my attention today.

Traditionally the bulk of the graduate school effort in training mathematicians has been made with the expectation that the successful graduates will seek college or university teaching positions; and, that some will carry on a collateral career in mathematical research. A number of excellent centers for such training have existed for some time in this country. Few such centers have emphasized applied mathematics, and little emphasis has been given to training mathematicians for service outside academic institutions. Within the last fifteeen years we have seen some growth in a few of our graduate schools in the fields of mechanics and applied mathematics. Today, in engineering education there appears to be a growing tendency to organize engineering graduate schools on a fairly large scale, as distinct from the older, more conservative forms of graduate school programs.

It is time for mathematics teachers and graduate school authorities to recognize realistically the demand for men trained for a wider variety of careers in the mathematical sciences than has been the tradition in this country. Mathematics faculties must accept an active responsibility in training mathematicians for careers in industry, as well as for careers in teaching and academic research. These faculties must realize that good research, development, and general mathematicians are needed in industry as well as in our institutions of higher learning. They must organize their efforts to train such men.

In order to lay a somewhat broader background for my theme, I shall review briefly the aims of university research. Later I shall discuss, in a general way, some aspects of industrial activities that bear on the theme.

Aims

The aims of a university are (1) to help individuals to learn more, and (2) to help mankind to know more. The mechanism whereby the first goal is approached is through teaching. The mechanism to realize the second is known as research.

University research ‡ has for its purpose the enlargement of man's understanding of the world, his fellow men, and himself. University research in science, and in engineering, must depend on underlying fundamental principles.

The engineer in university research is

* Retiring address of Chairman, Mathematics Division, 1953–54, presented at Annual Meeting of ASEE, Penn State University, June 22, 1955.

† The views expressed herein are those of the author and are not necessarily those of the Navy Department.

‡ "The Goals of Research," L. A. Du Bridge, THE JOURNAL OF ENGINEERING EDUCATION, Sept. 1954.

concerned with developing new materials, new practices, new methods of design; a more comprehensive understanding of fatigue, vibrations, thermodynamics, and so on. This is in contrast with the practicing engineer who is more likely to be concerned with actual design, construction and operation of structures, power distribution systems, and the like, making use of more conventional types of technology. The university research engineer is sort of intermediary to the pure scientist and the practicing engineer in industry.

The university engineer may be involved in activities which the industrial engineer feels is the work of the scientist, but on the other hand this work may not be of particular interest to the scientist, who may be interested in other types of things.

The university scientist engaged in research is usually engrossed in the frontier problems of his field. He is typically interested in his search for the understanding of new phenomena as contrasted with the development problems of utilizing his findings. Thus the research physicist in the university may be engrossed in the problems of sub-nuclear forces, or some highly involved studies in the propagation of sound through various materials, or the like, involving difficult or abstract experiments; whereas, such a physicist may not be interested in developing the fundamentals of the technology for these fields. There is much room for fundamental engineering research in the university atmosphere. Similar situations exist in other fields.

Physicists, chemists, and engineers, engrossed as they are in their particular types of research, can all make much good use of advanced mathematical techniques. But—who is going to create and develop the as yet undiscovered mathematical principles which can be drawn upon when the need arises? Who is going to develop such principles into suitable well-knit mathematical structures which the scientist and the engineer can lean upon for a better understanding, exposition, and prediction of the newer fields which he explores? This is the business of the competent research mathematician. It is a proper field for university research. This the research mathematician has been doing for many years. Such men have brought their talents to bear with great success in the many difficult problems of analysis, algebra, computation, and the like.

And who is it that is going to have the background of knowledge of the mathematical sciences and their interplay with the sciences, upon whom engineers and scientists can draw for collaboration and help in the solution of their problems? It is the mathematician trained specifically for these fields of application. He may be a university research mathematician, but he may equally well be a mathematician working in industry as a part of a team of research workers. The latter type of mathematician is not too common, and such as exist are not always well known outside the circle of their co-workers. He may not be the author of widely published research papers, but he may well be a real research man of major accomplishments in the fields of his activities.

It is these types of mathematicians which our universities must train, not only those for a life of teaching and academic research, but also those for a life of industrial research and development work in government and industry. Do our mathematics departments thoroughly appreciate these two distinct types of careers in mathematics? Especially the latter? Only a few of them do. Something should be done about this on a much wider scale than is now the practice in a relatively few graduate schools.

Steps Involved

But the type of research that I have crudely sketched for the university engineers and physicists is not by any means currently the practice of all universities, nor is this type of activity confined solely to universities. In industry and government we find a considerable amount of all

these types of activities, especially in the domains for research in physics, chemistry, and in the search for improved engineering methods, materials, design, etc.

It may well be appropriate to review some of the steps involved in the ultimate realization of a new product, or system. I have in mind such a thing as the development of a radically new type of propulsion system, or a new type of communication system, or the like. The realization of such a new system or product may more than likely involve a multiplicity of efforts, any one of which (as well as the system as a whole) may involve the following general steps: pure research, applied research, development, construction of prototypes for study, testing, etc.; the redesign of prototypes for limited production, the limited production of the redesigned prototype with subsequent evaluation, testing, etc.; the redesign for quantity production, aimed at removing the weaknesses disclosed to date, and at the realization of a readily reproducible system of uniform and reliable characteristics; the actual production; storage; marketing; and finally the maintenance of the resulting system in actual mass use.

At several stages in the realization of the desired system, careful analysis and evaluation of the system are absolutely necessary to disclose the characteristics of the systems, its utility, weaknesses, advantages, disadvantages, feasibility, reliability, and the like. Such analyses and evaluations commonly require the services of people of many talents. It has been found that mature mathematicians of sound judgment widely versed in the physical, economic, and statistical sciences are particularly well suited for this type of work.

All sorts of talents are made use of in such programs. In the pure research stage there may be no specific motive other than inherent curiosity, the search for new knowledge and understanding. Even later this stage may involve an organized program of search. It is in these stages that the true university research methods of mathematics, physics, and chemistry should be expected to predominate. Later when more of a specific phenomenon is known there comes a stage when the problems of utilizing the discoveries become of real interest. This stage introduces many real challenges and commonly carries over into a multitude of problems which fall naturally into the engineering research type of activity. The gap between the discovery of a new physical phenomenon and the actual utilization of the discovery may be a long and difficult one. From this, one works into the formal development stage with all its trials and tribulations, tests, failures, etc. Eventually a prototype is evolved which can be made to operate with some sort of reliability. From the experiences with such prototypes there is evolved a design suitable for mass production and with some hope of achieving a uniformly dependable production product. Not the least, of course, are the problems of marketing the system as produced and its subsequent successful operation and maintenance by people with little real knowledge of the system.

Various Talents Required

Each of these steps leading to a satisfactory system requires various types of talents. Experts in the physical sciences are apt to predominate in the research and applied research stages, while the research engineer is apt to play a dominant role in the applied research and development stages, the more practical type of engineer playing the more dominant role in the development, prototype, design and production stages.

The research mathematician may be expected to find his principal efforts in the pure, and to some extent, in the applied research stages. The applied mathematician may in general find his services most needed beginning in the research stage, but perhaps with much effort being expended in the applied research, design and development stages. His services

may be used in the analysis and evaluation of the system at various stages in the process.

A mathematician trained to participate in a program leading to improved systems, such as referred to above, may be required to work in many fields, and at times his work may be far removed from the type of research which academic mathematicians in this country commonly think of as mathematical research. But nevertheless the services of such a mathematician in industry and government can be of great value. He can bring to bear a tremendous background of knowledge and techniques in the arts of calculation, and of analysis. The more he knows of numerical methods and the limitations and potentials of computing engines; the basic fields of applied mathematics (electrodynamics, electronics, elasticity, dynamics and statics, thermodynamics, heat conduction, etc.); the principal fields of analysis (ordinary and partial differential and integral equations, calculus of variations, real and complex analysis, analysis in general); the great fields of geometry (differential geometry, tensor analysis, and related fields); the mathematical theory and practice of probability and statistics (including a basic knowledge of information theory); the structure of modern abstract algebra (including some number theory); and modern mathematical physics (both classical and quantum); then more useful he is apt to be. Obviously, such a background requires not only a good mathematical education, but requires, in addition, considerable study of some of the more theoretical branches of engineering and physics, some of which can be acquired in the undergraduate school, some later.

Such a background is in many respects a much more formidable one to acquire than one leading to a Ph.D. degree in some specific branch of mathematics. But it is such a background that a real applied mathematician should acquire somehow. Our universities must recognize such professions and provide for their training with the full realization that such talent will be normally expected to seek employment in our great industries rather than follow a career of teaching and academic research.

It is sometimes thought difficult to distinguish between the training for such a mathematician, as I have described, and that for a physicist or research engineer. Actually the difference is fairly easy to delineate. The physicist, engineer and applied mathematician do have much in common so far as their training is concerned.

Fundamental Distinction

Perhaps the fundamental distinction between the type of graduate mathematical training and the corresponding type of training in physics is in the development of an understanding and an appreciation for the structure of the analytical work—the mathematics; whereas the emphasis in physics (even theoretical physics) is on the physical development of the theories. In border fields either mode of approach alone is apt to leave one rather much in the dark as to the underlying structure of the reasoning used, unless specific attention is made to develop the theme from both points of view.

The training for the physicist is concerned primarily with the preparation for a life of search leading to a better understanding of nuclear or sub-nuclear forces, to the development of new theories which fit all the facts, and permit accurate predictions of experiments, theories which reveal a broad quantitative understanding of a field of physics. The training for the engineer (especially one trained for advanced work and research) is designed to prepare the student primarily for work which will result in the development and realization of new practices, new materials, new methods of design, better understandings of vibration, fatigue. Such training should fit one for work intermediate between the work of the pure scientist and the so-called industrial engineer; (the training for the industrial en-

gineer is aimed principally at the development of fundamental knowledge necessary to carry out designs, perhaps based on more traditional technology). On the other hand the training for the mathematician is concerned primarily with the development and structures of the various essential disciplines of mathematics. Thus a deep understanding of the underlying structure of abstract algebra (including group theory, invariant theory) will serve as an unusually valuable background for the understanding of various branches of physics; a well rounded foundation in geometry will help grasp and interpret many applications to modern physics, which as often written appear as specific examples or applications, with the results that the basic logical structure involved may not be understood (often not even by the writer of the physics). For example, a good background of the algebra and differential geometry underlying the theory of tensors, spinors, and the representation of groups, aids very materially in the understanding and knitting together of many current publications and efforts in the modern theories of the structure of physics.

In planning curricula for mathematics of the type described it should be realized that techniques change so rapidly that it serves little purpose to spend too much time on specific details of some specialized branch (e.g., quality control vs. a broad foundation in probability and statistics), rather the effort should be placed on the fundamental structure of the subject matter.

The deeply trained mature mathematician of judgment working in the fields of physical science, and of engineering, can often bring to bear a perspective, an overall approach, a generalization or common architecture which can contribute much to the understanding, explanation, and the knitting together of a large class of phenomena. Such a contribution when it can be made is often of great significance. He by necessity must cross many fields and hence must have a broad training in the foundations of a variety of topics.

Trend in Engineering Education

There is a trend in engineering education which we should review here in order to give a better perspective to my main theme.

Engineering training in some of its more difficult and advanced phases has much in common with the training for a career in physics. So much must be learned for the various types of engineering work that four or five years of college is insufficient to give the broad scientific and fundamental knowledge needed. Six and seven years of schooling on the professional level is often necessary, and this type of training is not necessarily the same in spirit and practice as the traditional seven years of undergraduate and graduate work leading to the Ph.D. degree.

The mathematician has long known that he must spend seven or eight years of college work in order to lay a broad background for a teaching or research career in mathematics. Physicists and chemists have some to know this, too. The engineers are feeling this need in some quarters now.

It is my contention that professional schools beyond the usual four years of college or university must recognize that there are two distinct approaches and perhaps goals in any training for the fifth to seventh years—the usual graduate school period. One approach may be termed that of the professional school—leading to some sort of advanced professional degree or certificate; the other, the more traditional graduate school approach—leading to the Ph.D. degree of comprehensive standards.

I claim that in most branches of engineering and physical science—and in mathematics—that this division of effort and emphasis is a healthy and desirable one.

We should design the fifth to seventh year mathematical offerings towards:

(a) a professional career with appropriate training and experience, leading to an appropriate degree or certificate.

or

(b) a traditional graduate school training leading to the Ph.D. degree, with the principal emphasis upon training for research in a highly specialized atmosphere.

For example, in mathematics, there are gifted students who are really not cut out for careers in pure research and teaching, but who are really gifted in a way which will make them admirably suited for careers in industry. I refer to careers where a highly technical training in the mathematical and physical sciences is necessary for the work, but where the special talents and interests of such individuals are such that they can contribute much more of benefit in industry than in pure research and teaching. Students competent to follow either of these types of advanced work are generally of superior talents and potential abilities.

A broad training in mathematics, engineering, and science will be of more value to many professional students than a more narrow training and specialization into some highly refined branch of mathematical research. Both types should be encouraged, but we should be very sure that in shepherding talent toward purely mathematical research we do not forget the other types of professional mathematicians.

Our colleges in engineering and physics are already doing much along the lines I have been talking about under the broader category. We in mathematics should do more of this type of work too, in cooperation with other fields. Well-trained mathematicians, with some background in the physical and engineering sciences, have much to offer.

In other words, I am advocating strongly a "new look" at the philosophy of educating mathematicians in our mathematics departments.

True, some institutions are doing striking things along these lines, but I say too many are *not*—as yet.

Conclusion

To conclude, it appears beyond doubt that much more attention must be paid to the training of mathematicians for careers in industry than has been traditional in this country.

A professional school of applied mathematics not necessarily directed toward pure mathematical research but directed toward a wide and broader field of training, which will prepare the student for a very wide variety of useful professional service in almost any branch of engineering, science, economics, etc., should be provided. This training may or may not lead to the Ph.D. degree, but should lead to some form of higher professional degree or certificate.

In carrying forward this program it is furthermore urged that a continuation of the traditional training for the Ph.D. degree in research and teaching of mathematics must be encouraged. This should be done in the atmosphere of the true graduate school in the broadest sense with emphasis toward research.

It is the responsibility of mathematics departments to sponsor both types of training; and often the first type when only little of the second type can be done.

And finally, may I emphasize the importance of crossing subject lines; make the professional course with the major in mathematics one overlapping into many fields. Research and development in the world is not "topology" alone, or "numerical methods," or organic chemistry, or philosophy. It is a blending of any and all known disciplines into a homogeneous system designed to end up in something of better use to all men.

Train mathematicians for service and see that their sights are kept broad, with real breadth of vision.

Cracking the Creative Nut

By DONALD S. PEARSON

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Industry today is clamoring for engineers who not only have the ability to solve related problems in various fields but especially those who are able to recognize problems and *do* something about them. This need is destined to become even greater and greater.

A close look at the senior or graduate student in our engineering colleges quickly reveals a weakness in his ability to use the physical principles, and mathematical laws relating such principles learned in his formalized courses. To solve a problem based on methods covered in a text is one thing, but to apply the methods learned from several sources to new and outside problems, either of his own choosing or those presented to him, is an entirely different situation.

Recognizing this as a problem requiring educational attention, I should like to relate briefly how I approached it. At the outset, my interest and background is largely the result of participation with industry as a staff member in several Creative Engineering Seminars, and my activity as an electrical design engineer and teacher.

In the spring semester, 1955, a course entitled Creative Methods was offered by the Electrical Engineering Department to senior and graduate students for a maximum of three credits. The course was divided into a one hour recitation and a two to three hour laboratory each week.

The one hour recitation period served to establish a background in "Applied Imagination" based on the text of the same name by A. F. Osborn. I found assimilation of the text rapid and discussions indicated that the students found it interesting from a psychological and philosophical viewpoint, and diversionary from the usual engineering course. Supplemental to the text, mimeographed class notes, outlines and other practices together with a bibliography were distributed at the appropriate time. Selected reports were assigned and discussed in class. Responsibility was placed on the student to report on current articles and maintain an up-to-date bibliography. Along with oral quizzing, these factors were taken into account in grading. It might also be added that other bases for grading were his participation in the group as a member and leader, the quantity and quality of his creative effort as evidenced by his reports, and a final examination.

The philosophy that he could be trained to use his own talent more productively by systematic practice of the principles and procedures set forth, led at once to these practices in the laboratory session. The goal of each man was at least one creation as evidenced by a report including drawings, sketches or models. There was no limit placed on the number of creations but it was suggested that these be restricted to his own field of endeavor. Creating has been defined as " a combination of things or attributes that is new or different to him or to those about him."

One of the striking points brought out in the first laboratory period was the great difficulty encountered by the seniors in finding or recognizing a problem. However, two graduates, employed full-time in a research organization, had little difficulty in this respect. Here was a problem facing the group: i.e., *"what are the problems and where are they found?"*

In order to gain practice in group techniques, no restrictions were placed on the types of problems in this early stage of the course. A "brainstorm" session revealed a number of problems for group consideration such as "anti-upset device for farm tractors," "automatic automobile decelerator," "automatic safety brakes for holding cars or trucks on hills" and many others of this nature. Each member then selected, with the approval of the instructor, a problem of his own choosing or one revealed in the "brainstorm" session. He was allowed as much group help as he could get to assist him in solving this problem in a scheduled time limit. He was to demonstrate its effectiveness, by report.

During the preliminary six-week period, a technical problem was assigned a week in advance of its approach by the group. Each member was asked to think about its solution during the week. As a thinking prop he was asked to keep a sheet of paper in his notebook in which to write any and all problems relating to electrical engineering as a result of this course or any other experience. During the ninth week he was asked to make a selection from the list just mentioned and report the title to me for a final project or in lieu of this I would make a problem assignment.

It was not the purpose of this article to make a detailed evaluation of the results. However, briefly there have resulted several patent applications and disclosures and it might be of interest to mention at least one of these. This was a "constant current direct coupled amplifier" capable of a 0–100 k.c. response using two tubes (one bottle) with a voltage gain of 1300. This amplifier uses a single 250-volt supply with no negative supply voltage and has a current drain of less than 15 ma.

Conclusion

The following comments concerning the value of the course have come from the students;

1. He has acquired practice in applying theory and gaining confidence in his ability to solve problems.
2. He has acquired a technique for solving problems which applies to individuals as well as groups.
3. He has learned to cooperate with others and respect their points of view.
4. He has learned to evaluate by approximation before making decisions.
5. Stimulation of his ideas has in turn stimulated others.
6. The sense of accomplishment is an incentive to bigger and better things.

As for the instructor, it might be said that;

1. The course is a challenge to teaching and in equal measure an inspiration.
2. The important thing about progress is change and an open mind is imperative.
3. Flexibility is the keynote in tailoring the course to the needs of the group.

Special Notice

The Proceedings of the Eighth Annual Conference on the Administration of Research are available from the New York University Press, New York City. Pp. 108. Graphs, figures. Paper bound. $4.00. Included in the volume are talks on appraising and rewarding the researcher's output (merit raises), management in the research laboratory, communication problems in a research laboratory, physical facilities for research, and basic research in an applied research laboratory.

The Role of the Colleges in Nuclear Engineering Education*

By G. A. HAWKINS

Dean of Engineering, Purdue University

I. Introduction

The sudden advent of atomic power in war and peace has created some confusion in the minds of many educators and industrialists as to the immediate and future needs in the education of engineers for the new nuclear industry. In this presentation some views as to the requirements, and the responsibilities of the colleges and universities to fill inadequacies, will be offered for your consideration.

A recent opinion poll taken by the ASEE Atomic Energy Education Committee indicates that engineering educators are vitally interested in obtaining as much information as possible on the subject. The committee prepared a questionnaire stating that in order to formulate a program of maximum value, they would appreciate an indication of which of the following plans would be of greatest benefit to the institution:

A. "Having an individual who is an authority in the field and who understands the problems of engineering education visit your institution to discuss atomic energy education with interested members of the faculty, and to suggest procedures that might be used."

B. "Having a team composed of authorities visit your institution to discuss the problems with interested members of the faculty."

C. "Having a report prepared and distributed describing various procedures that could be utilized in incorporating nuclear science into the engineering curricula."

D. "Sending representatives of your faculty at your expense to regional conferences devoted to the subject."

Replies were received from 138 of the 147 institutions contacted. The majority requested Plan C as the first choice, and Plan A as the second choice. Plans B and D lagged far behind C and A from an interest standpoint.

In response to the need expressed by the educators, the Committee is now actively engaged in compiling data for use in the preparation of a report based on Plan C.

Information gathered thus far tends to indicate that the need for engineers in the nuclear industry may be grouped into three classes.

1. The first is an immediate requirement for engineers to work in:

   a. AEC Contractors' facilities.
   b. Colleges and universities to aid in planning suitable educational programs.
   c. Those industries involved in the design of nuclear power plants and related equipment.

Many of the engineers entering the field will need on-the-job training to aid them in developing the necessary background.

2. The second is a requirement for the education of students who have the necessary background and are interested in

* Presented at the Annual Meeting of ASEE, Conference on Atomic Energy Education, Penn State University, June 22, 1955.

entering the field in functions such as design, development, and research.

3. The third is a future need to educate engineers for other functions such as maintenance, operations, sales, etc. This requirement will become more pressing as the industry expands.

II. Educational Programs.

The educational programs which may assist in relieving the present pressing need for engineers and for the future requirements may be classified in the following manner:

A. Undergraduate Engineering Education.

An undergraduate educational program for the engineer based on the ideas advocated in the report of the ASEE Committee on The Evaluation of Engineering Education appears to be well suited for students interested in entering the nuclear industry. By means of a strong core of the physical sciences and the engineering sciences together with sufficient flexibility in electives, the student may begin to prepare himself for future work in the area of nuclear energy. Many of the existing professional programs do not afford enough flexibility to enable the student to obtain the desirable physics background for work in the atomic energy fields.

The need for an educational introduction to the nuclear field may be filled by:

a. Establishment of curricula in nuclear engineering. This plan has already been placed in operation at the North Carolina State College at Raleigh, North Carolina.

The program contains more basic science and engineering science courses, and less material of a specialized nature than is now incorporated in many engineering curricula.

b. Providing flexibility in existing programs.

A sufficient number of courses could be introduced in place of technical electives to give the student the necessary background for nuclear work, if greater flexibility could be provided in the curriculum.

c. Introduction of nuclear material in existing required courses.

Some introductory nuclear material could be introduced into existing required courses in the undergraduate engineering programs. This would allow all of the students to become acquainted with the subject.

At the present time only students who have an aptitude for research, development, and design should be encouraged to take such a special curriculum or specialized elective courses. Only after the industry has grown and need arises for engineers in functions involving construction, operations, sales, etc. should other students be advised to carry courses in specialized subject matter. The colleges and universities engaged in engineering education will have to provide the suitable academic atmosphere and instruction to enable students interested in atomic energy to enter the industry especially qualified for work in the field.

B. Graduate Engineering Education.

The short and long term need for engineers having advanced training is definitely a responsibility of the colleges and universities. Opportunities should be afforded graduate students to undertake academic programs and to do research in preparation for future work in the nuclear industry. Many institutions are already offering study plans in the nuclear engineering area.

A number of educational institutions and the National Laboratories are cooperating to enable graduate students to work on their theses in the laboratories after having completed course work at their respective college or university.

C. Adult Education.

The universities and colleges may contribute significantly to the development of engineers who did not have the necessary courses to study as students, but who de-

sire to enter the nuclear industry. These practicing engineers may be divided into the following groups for purposes of discussing possible programs:

1. Practicing engineers employed in various industries who desire to enter the nuclear industry.
2. Recent engineering school graduates interested in entering the nuclear field.
3. International students.

The U. S. Government has established a policy of encouraging international engineers to study nuclear subjects in this country.

The colleges and universities and the governmental laboratories are handling the demands for the education of their groups at the present time, but in order to keep pace with the developments additional opportunities must be made available. Some of the methods now in use follow:

Colleges and Universities.

a. By offering both day and night regular term courses in physics and nuclear science.

b. By concentrated periods of instruction at the institution for periods ranging from several weeks to full terms.

c. By concentrated short courses of only several weeks duration.

d. By correspondence work.

Governmental Laboratories.

a. Special technical programs of varying lengths.

Laboratories such as the Argonne and Oak Ridge installations have established specialized programs of study of varying lengths of time. An example is the Oak Ridge Institute of Reactor Technology.

The Argonne National Laboratory is now offering a program of study for international students.

b. Special courses and lectures for employees.

Many of the national laboratories and AEC contractors offer special courses for their employees and others in order to enable interested persons to expand their knowledge in this field.

III. Research.

If a graduate program is to be established, then research in the area is a vital necessity. Research activities in the field of atomic power may be carried out by a university in a number of ways, some of which are listed as follows:

1. Basic research.

The National Laboratories have encouraged the colleges and universities to undertake basic research in the field. Many of the problems can be studied without a reactor. Support for this type of research may be obtained through funds from industry and governmental sources. Some universities are also contributing funds to encourage members of their staff to undertake research in the area of nuclear engineering.

There are also a number of worth-while problems, but less basic, which are of interest to individual staff members. This research can be carried out under similar arrangements.

2. Cooperative research programs with National Laboratories where the student completes his research at one of the Laboratories after the formal course work has been finished at an educational institution.

IV. Staff.

In order to offer course work and to conduct research at an educational institution, it is necessary to have members of the staff thoroughly familiar with the subject. Since it will not be possible to recruit enough qualified persons from the nuclear industry for teaching purposes, it will be necessary to encourage present staff members to take an active part in the development of the program. Education of the staff in this area may be accomplished in a number of ways, some of which follow:

1. Leave of absence for work at a National Laboratory.

2. Leave of absence for work in an industry closely allied with the nuclear power field.

3. Leave of absence for study at institutions having established courses.

4. Cooperative consulting arrangements with National Laboratories and industries engaged in developments in the field.

5. Attendance at short courses and conferences.

6. Reduction of time devoted to normal academic work to provide time for concentrated self-study of the subject.

7. Conferences and seminars conducted by qualified authorities in the field held on the institutions' campuses.

8. Appointment of qualified visiting professors for a period of one to two terms.

V. Conclusions.

From all indications the nuclear industry will expand at a very rapid rate. This will create a demand for engineers professionally qualified in the area. In order to fill this need, the colleges and universities must assume their share of the responsibility to provide engineers to work in the nuclear industry.

College Notes

Dean Edward R. Stapley of **Oklahoma A. & M. College** has retired and been named dean emeritus of A. & M.'s Oklahoma Institute of Technology and professor emeritus of civil engineering.

Dr. Newman A. Hall has been named to head the Graduate Division of the **New York University** College of Engineering. Dr. Hall will serve as assistant dean and professor of mechanical engineering. He is also chairman of the Graduate Division of the ASEE.

Frederick E. Terman, dean of the Stanford School of Engineering, has been appointed provost of **Stanford University**. He will continue as dean of engineering, also.

Chester A. Arents, coordinator of research and professor of mechanical engineering at Illinois Institute of Technology, has been named dean of the college of engineering at **West Virginia University** to replace the retiring dean, Dr. Roland P. Davis.

Physics Is Not Engineering*

By R. J. SEEGER

Assistant Director, National Science Foundation

When I began teaching general physics I was assigned responsibility for the part on electricity and magnetism. In attempting to correlate the lecture and recitation material with the laboratory manual I found myself beginning the course with familiar electric currents (instead of electrostatics) and then utilizing a phenomenological concept like conductance for parallel connections (instead of resistance). One day I was telling a colleague, a professor of electrical engineering, about my teaching problem and my unorthodox solution. To my surprise I learned that I had been using the customary approach of electrical engineering. Of course, I suppose that I should have suspected it inasmuch as the laboratory text had been written by a professor of physics with an electrical engineering background. I was disturbed. Was I really teaching physics or electrical engineering? This was my first introduction to the no man's land between physics and engineering. As I now look over that same territory, however, regardless of similar pedagogical techniques, I am convinced that "physics is not engineering."

The engineer is certainly concerned primarily with creative design. He makes use of known information, such as the availability of materials, their cost, and safety requirements. Unfortunately, owing to insufficiency of data or time he is often compelled to make a decision despite many facts still being unknown. The physicist, on the other hand, is engaged primarily in creative research. He attempts to understand phenomena and to determine their underlying principles. He, too, starts with certain known observations and familiar concepts and then imagines a broader picture to include also the unknown. His problem, therefore, is essentially a theoretical one; it lacks the critical urgency of practicality. The physicist is not time bound. In this important sense physics is not engineering.

Most of us I believe would have subscribed to this distinction between the physicist and the engineer a decade ago. The outline, however, has recently become somewhat hazy owing to the innovation of the term "engineering science." One may emphasize the adjective engineering, in which case engineering science is essentially a body of scientific knowledge useful for solving practical problems. On the other hand, one may stress the noun science so that engineering science may be regarded as genuinely basic science involving phenomena relating to engineering problems. In this sense, of course, physics itself might well be designated an engineering science. The historical evolution of much of engineering from physics justifies this point of view. In this connection I am reminded of Professor E. Weber's definition of engineering science as those parts of chemistry, mathematics and physics that are no longer of primary interest to chemists, mathematicians, and physicists. My only criticism of this definition is that it presupposes less interest nowadays in certain phenomena by physicists. The fact is, however, that there are more physicists interested in these very phenomena today than ever before. At the same time, it is true, there are many

* Invited address at the Winter General Meeting of the American Institute of Electrical Engineers in New York, 1955.

more physicists altogether so that the absolute increase is concealed in the relative decrease. Thus we find today that the physicists have a genuine research interest in physical mechanics, corresponding to that of engineers in engineering mechanics, in physical thermodynamics corresponding to engineering thermodynamics (from the viewpoint of the chemical engineer and of the mechanical engineer), in physical electrodynamics corresponding to engineering electromagnetism, in physical electronics corresponding to engineering electronics. As a matter of fact these different viewpoints of the same subject might result in a false dichotomy. The viewpoints are certainly distinctive, but the object is common. From this standpoint I view with some concern the present attempt to draw a sharp line between so-called engineering sciences and basic sciences. Whereas I realize that the physics viewpoint is not the engineering viewpoint, I am confused over the concept of the engineering scientist. Is he a scientist or an engineer? Or is this merely a way of calling attention to the increasing scientific basis for engineering? Perhaps we can dismiss this semantic difficulty with Juliet's reminder:

"What's in a name? that which we call a rose
By any other name would smell as sweet."

Let us turn now to the problem for discussion today, namely, the teaching of electricity and magnetism in general physics. The guiding light, I believe, is a presentation of interrelated principles and concepts from a truly modern viewpoint. For example, the children of yesterday played with pith balls and magnets, but the children of today, like my son, John Mark, age six, play with toy transformers. Hence I suggest that we must begin our instruction not historically but rather systematically from today's vantage point. In order to understand electricity, however, we need to look first at mechanics.

Evolutionary in its Development

Popular opinion notwithstanding, physics is essentially evolutionary in its development, not revolutionary. Science, moreover, cannot be divided into separate and unrelated sections. Thus all physics is rooted in mechanics with its great conservation laws of momentum and energy or mass. True, these generalizations developed out of Newton's laws of motion and were later extended to phenomena of thermodynamics and electrodynamics with the resultant widespread philosophy of mechanism. If we are to view electrodynamics today, we must do so from the background of mechanics. In this connection, however, it is not so important that we see superficial similarities between Newton's law of gravitation force and Coulomb's laws of electric force and of magnetic force. Rather we should realize at the start that we are dealing in electrodynamics within an entirely different type of force from the central force encountered in mechanics, namely, the type of force experienced by a small magnet near a moving electrically charged body, a force that acts not along the line from the magnet to the body but at right angles to it. Moreover, the very intensity of the force depends not just upon a scalar quantity like the distance apart, but upon a vector quantity like the velocity of the body. In order truly to appreciate these differences, however, it will be necessary to understand thoroughly the common mechanics background of physics.

Electrodynamics, we soon realize, has its theoretical description based largely on the concept of a field of force, which certainly ranks as the most important concept introduced in physics since the advent of Newtonian mechanics and as the culmination of the classical method. For example, if we look at a bar magnet, we see a rectangular piece of iron carrying no electric current. At the same time, if we look at a copper helix carrying an electric current we observe a solenoid. On the surface these two objects appear to have nothing in common. Yet the phenomena

are indistinguishable in their external electromagnetic effects of attraction and repulsion. The field which describes these phenomena takes on a greater physical reality than the sources of the phenomena themselves. Therefore, if we wish to understand the phenomena, we should begin with the field as a model, not with electric charges, not with magnetic poles, not even with elementary particles. Strangely enough, to understand the properties of such materials we must study the field in the empty space between them.

Michael Faraday is remembered for his persistent investigation of electric and magnetic phenomena. The mathematical description of them is due to Clerk Maxwell. The Maxwell equations for a vacuum describe the history of the field, as Newton's equations give the history of particles. They form a pattern for a new type of physical law which holds throughout all space and not merely at those points where matter is present as in mechanics. Thus we naturally begin with the simplest of fields, the electrostatic field about an electrically charged body, and then we consider the static electric field in a conductor carrying a steady electric current. Such a conductor, of course, has also a magnetic field, which is the next topic to be studied. We are reminded historically that it was H. C. Oersted who first noted the magnetic effect of an electric current, that it was A. M. Ampère who then conceived of elementary electric currents accounting for macroscopic magnetic effects, and finally, that it was H. A. Rowland who showed experimentally that a convected electric charge does, indeed, produce a magnetic effect. From the study of steady fields one investigates next changing electromagnetic fields, which produce displacement currents with their associated electromagnetic waves. Here we find ourselves considering radiation, both the long-range coherent waves in wires and the short incoherent waves of dipole radiation. Certainly at this point modern students must be made to realize the significance of the constancy of the velocity of light in a vacuum, which fixes a limit on the effects of radiation and necessitates a relativistic point of view in order to establish the invariant properties of these phenomena.

Having discussed Maxwell's equations for free space, we consider next the electric and magnetic behavior of material bodies, namely, electrical conduction, first in a vacuum and then in metals, dielectrics with polarization, electrical origin of magnetic properties, including poles in magnetic materials resulting from electric currents, and finally, electromagnetic waves in material media, with their properties of reflection, refraction, dispersion, scattering, interference, diffraction, and heat radiation. In this way we view optics as a branch of electromagnetism. Naturally we are concerned primarily with physical optics and regard geometrical optics essentially as a physical approximation valid only under certain geometrical conditions. In considering optics, however, we must consider the momentum of electromagnetic radiation. Here we are confronted with another limitation of theoretical investigations, namely, the impossibility of measuring with unlimited precision simultaneously the momentum and the position of a particle. Another fundamental constant of nature, namely, Planck's constant, tantalizes us here with its universality.

In this view of general physics, mechanics with its particle concept naturally represents the first phase. Electromagnetism, with its all important field concept, is the second phase. Modern physics as a third phase, strictly speaking, begins with the theoretical significance of the limitations of measurements due to the universal character of the velocity of light and of the quantum of action. It may be recalled that Lord Kelvin at the close of the 19th century referred to these two experimental facts as the only clouds upon the broad horizon of classical physics, clouds that became respectively the relativity theory and the quantum theory of the 20th century.

What is Physics?

So much for the content and sequence of a beginning physics course in electricity and magnetism, which I regard as being necessarily the same for any scientific introduction, whether for an engineer or for a scientist or even for a humanist. A different spirit of inquiry, however, may be used in each approach. This necessarily involves the question, "what is physics?"

We all agree that physics is a basic science. But what is a science? Do we mean the same thing when we say domestic science? political science? divine science? Christian Science? We might take the etymological notion that science is knowledge, with the reservation that we mean here systematized knowledge in the sense of German *wissenschaften,* which covers all knowledge. On this basis in medieval times science included both secular philosophy and revealed knowledge. According to the modern positivistic viewpoint, however, science is thus identified with philosophy. "The question is," said Alice, "whether you can make words mean so many different things."

What is science? May I suggest as a starting point that we regard science as the cumulative result of the use of the scientific method. In this connection I am quite aware of Dr. Conant's objection in *Science and Common Sense:* "There is no such thing as *the* scientific method." I submit, however, that his conclusion follows from his own restrictive definition. It is a matter of taste whether one believes that there are essentially different methods, or one general method with different degrees of success dependent on materials investigated, that is, physical, biological, social. To me *the* scientific method involves essentially questioning, with the ever present possibility that stupid questions can result only in stupid answers. One begins, however, by asking questions of nature. The answers are the observed facts. One looks for related factors among them and then tries to synthesize all with a factitious theory. From this vantage point one asks new questions and so the cycle repeats without end. One always begins with phenomena and then subjects theoretical conclusions to two criteria: (1) comparison with the phenomena themselves, and (2) review under the testing light of common expert opinion. It is important to realize that science is neither essentially empirical nor solely rational. It is not simply deductive or simply inductive, but rather an interplaying combination of these two procedures. The theory resulting from the use of the scientific method is meritorious in so far as it describes what is known and predicts what is unknown.

In all this we note the major role of the scientist himself. In view of the fact that the scientific method is really nothing more than what is used by the scientist, we find the scientist continually selecting—first, facts, then factors, and finally theory itself. Throughout the entire investigation he is using creative imagination. What is most important is not his sight but his insight, not so much the things he sees as what he sees in things. Thus the laboratory is like an art studio, like a kindergarten. In short, physics is fun. Whatever other by-products of the teaching of physics may exist, unless the student is enjoying the course, it is a failure. This one criterion I would propose as a measure par excellence of the effectiveness of physics teaching: is it fun?

In this connection I believe it is important that we get historical perspective by seeing how other persons discovered nature's secrets in the past, and that we get philosophical breadth by appreciating the limitations of our own theoretical views. Above all, the student should be shown the vista of relations among apparently unrelated phenomena such as a magnetic stone found in Asia Minor, an amber pebble picked up in the Baltic Sea, and a frog being used for biological demonstration in Italy. The student should be warned at all times of the danger of greater respect for the expressed word than for the

unexpressed thing, for which it stands symbolically. The thing is all important!

The student should even be encouraged to challenge the accepted order of things, so-called common sense. It will be recalled that in investigating the conduction of electricity in solids the 18th century was faced with a dilemma between two theories, the one-fluid theory and the two-fluid theory. On the other hand, in investigating the conduction of electricity in liquids, the 19th century faced another dilemma as to whether electricity is inherently continuous or atomistic. No one bothered, therefore, with the conduction of electricity in gases, which was regarded as just another instance of conduction. Hence Crooke's tubes at the close of the century were only playthings of science. Yet it was in the investigation of the conduction of electricity through gases that we found the answers both to the dilemma of the 18th century and to that of the 19th century, namely, the discovery of the electron.

Summary

In summary, even though engineering *must* be taught as an application of principles to practical problems, and even though science *can* be taught as a body of principles themselves, I believe science *should* be taught necessarily as a curious scientist's probing method to understand natural phenomena. In this respect, certainly, physics is not engineering.

College Notes

The nuclear option of the Department of Chemical Engineering of the **Polytechnic Institute of Brooklyn** had its formal introduction when 12 senior undergraduates started taking the new courses during the 1955–56 academic year. These 12 students have already taken the necessary basic courses in nuclear and chemical physics last year in preparation for the option. Although a minor specialization in the chemical engineering curriculum, the nuclear option will give chemical engineers a strong foundation in both the theory and technology of the processes involved in the production of power through nuclear energy.

In addition to the undergraduate program, Polytechnic's graduate school for the first time is offering courses in the field this fall. These basic courses are open to part-time students without previous experience or prerequisites in the nuclear field except an academic background in chemical engineering.

A teaching professorship in chemical engineering, believed to be the first industrially-sponsored university chair specifically limited to undergraduate instruction, will be established at **Cornell University** with funds given by Socony Mobil Oil Company, Inc.

A nationally recognized chemical engineer, between the ages of 35 and 45 and with strong industrial experience, will be sought to fill the chair, which will be created in Cornell's School of Chemical and Metallurgical Engineering. In accordance with the agreement between the university and Socony Mobil, the professor will be encouraged to consult with industries served by chemical engineers. This is intended to help keep his teaching in close relationship to industrial problems and trends.

The agreement provides that Cornell has "complete freedom to select the professor and determine the manner in which teaching shall be conducted." Socony Mobil will give $60,000 to underwrite the professorship for an initial five-year period. In addition to the professor's salary, the fund will cover travel and other expenses related to the chair.

Ways to Increase Prestige and Improve Status of the Good Teacher*

By LEE H. JOHNSON

Dean, College of Engineering, Tulane University

(For the subcommittee of the Committee on Recognition and Incentives for Good Teaching)

This discussion springs from the work of a subcommittee of the Committee on Recognition and Incentives for Good Teaching. Its membership has consisted of Professor R. P. Hoelscher, University of Illinois, Professor Clyde R. Nichols, Purdue University, and Lee H. Johnson, Tulane University. All members of the Committee have contributed to the ideas which are expressed here.

The subject for discussion is rather difficult because it is hard, if not impossible, to find a definition of a good teacher to which all would subscribe. Different definitions lead to different approaches to the subject. Consequently it will be assumed for the moment that everyone will agree that good teaching is recognizable and the discussion will begin with ways to increase prestige and improve the status of teaching.

There is an old saying that "all roads lead to Rome." An over-simplification of the answer to our question might be paraphrased to say that "all ways of increasing prestige and improving status lead to recognition and reward." Recognition and reward are not necessarily two distinct things in themselves for although recognition of one sort may lead to reward in terms of promotion and increased income, recognition of another sort may in itself constitute a reward. Accordingly no attempt will be made to separate these in our discussion.

Let us re-phrase the subject for discussion as "ways to obtain recognition and reward for good teaching." Certainly nothing shall be forthcoming if nothing is known of the work of a good teacher, so the question resolves itself into channels of communication. This matter of communication is of primary importance. As Mr. Richard W. Schmelzer, Chairman of the Committee on Recognition and Incentives for Good Teaching, recently wrote, "The crux of the problem is this: how can we assign a quantitative value to good teaching?" How can we bring to light tangible evidence of superior instruction?

There is definite belief that recognition and reward for research are greater than for teaching. If this is true, perhaps it is because the results of research are more immediately seen in the form of reports and publications and because research can be lucrative to an institution. These are rather tangible things which are easily communicated. The subcommittee has approached the matter of communications by classifying the various ways of communicating the work of a good teacher and outlines them as follows:

Institutional:

Reports of developments and achievements each year to the Department Head and the Dean.

Reports by the Dean to the President and the governing board.

Letters and other expressions from former students.

* Panel discussion at Annual Meeting of ASEE, Educational Methods Division, Penn State University, June 20, 1955.

Departmental and school conferences on the objectives and methods of teaching which will bring out good work already being done.

Appointment to a committee or a group to work with beginning instructors.

Professional Recognition:

Papers on educational methods at ASEE meetings.

Papers on educational methods at local engineering society meetings.

Local and national awards by professional groups, medals, certificates, prizes and such.

Text books and other publications.

Industrial Recognition:

Industrial consulting on educational or training problems. Perhaps this is a new field which has not been explored for the talents of the good teacher.

Public Recognition:

Television and radio programs on such subjects as the art of teaching, engineering as a creative profession, vignettes of college teaching and such.

Newspaper and magazine announcements of achievements and awards.

Local and national civic or industrial awards.

The foregoing list is not intended to be a complete statement of ways to bring recognition and reward. However, it does imply that something is being done which is worthy of recognition and reward. Just how much is being done? We have all heard many times that "It's hard to keep a good man down." If there are many, many outstanding teachers, creative in their thinking and stimulating and inspiring to their students, it is hard to believe that this forceful group would long remain submerged. Perhaps many of those who would have become great teachers have had their energy and thought diverted to research or administration. Perhaps, also, not enough attention has been focussed on the opportunities for research in teaching which would lead to achievements not easily overlooked by colleagues in research and administration. Certainly patterns in teaching seem to follow a rather restricted path and strongly resist change. It is understandable that materials of engineering and the physical and chemical forces of nature are easier to work with than habits and attitudes of human beings.

This suggests that one of the fundamental problems in increasing the prestige and improving the status of teaching is to make the profession acutely aware of the tremendous area in teaching which remains unexplored, to make it aware of the great opportunity for research and creative thinking within the classroom itself.

Examples

A few specific examples may serve to illustrate this idea sufficiently. Generation after generation of engineering students has been taught mechanics in the sequence of statics, dynamics, strength of materials, and hydraulics or fluid mechanics. Is this sacred, or would statics and strength of materials taught in sequence followed by dynamics and fluid mechanics as a second sequence be a better arrangement?

It has been said that courses such as statics or dynamics are set. The implication is that nothing can be done to change the way those courses are taught because the subject matter is rigid and unchanging. There is no argument possible about the correctness of the principles of static equilibrium or of Newton's Laws of motion in these courses. And so the entire emphasis is on a type of problem in which the conditions are completely specified and which has a unique answer. How many instructors in mechanics ever give problems in which each student would get a different answer? For example, one problem might be, "Time yourself in running from the ground floor to the third floor of a building and compute your horsepower." This involves techniques of

measurement and some choice on the part of students as well as the application of elementary principles of dynamics. Arguments between students who choose different methods of measurement or different conditions for obtaining data may well bring out other aspects of dynamics as well as of measurement.

Again, another problem might be, "Make a close estimate of the forces which keep the trunk lid of an automobile open. Outline carefully your approach to the problem and the methods used. Accompany your solution with a neat, dimensioned, free-hand sketch." This problem introduces a number of factors which must be considered by the professional engineer in practice while it requires the application of the principles for static equilibrium. Different methods of measurement will be used and different methods of supporting the trunk lid will be presented. Elements of report writing are inherent in drawing up the problem for submission to the instructor.

These are but two of thousands of examples to indicate opportunities for research in teaching. Perhaps the best way to increase the prestige and improve the status of teaching lies in a renewed attack upon time-worn ideas and hackneyed methods in teaching.

Special Notice

The National Science Teachers Association, 1201 Sixteenth St., N.W., Washington 6, D. C. announces the publication of the following booklets:

Careers in Science Teaching. (1955–56 Revision). 22 p. $8\frac{1}{2} \times 11$. Illustrated. Free in limited quantities. On the way, on the job, and opportunities open to general science, biology, chemistry, physics, and mathematics teachers.

* * *

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The Prediction of Engineering Potentiality in High School Students*

By A. PEMBERTON JOHNSON

Testing and Guidance Division, Newark College of Engineering; Formerly Project Director, Educational Testing Service

The effectiveness, the cost, and the limitations of the prediction of engineering potentiality among high school students are of vital importance to our nation today. Apparently there is growing acceptance among parents, among high school students, and among secondary school teachers and administrators that *there is a shortage of engineers.* The heavy recruiting activity among engineering college seniors and juniors together with the high salaries being paid to them has become known in home and school. As you know, the aircraft industry has recently sought draft deferment for engineers. There has been concern recently that the Russians have outstripped us in military aeronautics. The Hoover Commission has recently recommended more spending for research and development to improve our scientific, engineering and production capabilities. In the March 1, 1954 *Newsweek*, Dr. Vannevar Bush, Head of the Carnegie Institution in Washington, D. C., was quoted as saying, "There seems to be no doubt that they, the Russians, are training more scientists than we are. They screen the country for talented kids more than we do. We are enamoured of the idea of mass education. Curiously, the Russians, despite Communism, extend special privilege to gifted youth, if we can believe anything we hear about them. We, on the other hand, still let too many gifted youths slip through our hands."

Recently Dr. M. L. Trytten of the National Research Council, Dr. Howard A. Meyerhoff of the Scientific Manpower Commission, and Mr. William T. Cavanaugh, Executive Secretary of the Engineering Manpower Commission, have pointed out the serious shortage of secondary school teachers who have the background to give sound and inspiring courses in science and mathematics. To improve the teaching of science and mathematics in secondary schools the Carnegie Corporation of New York has recently made a grant of $300,000 (announced early in June) to the American Association for the Advancement of Science. I am extremely hopeful that this grant will make possible a marked long-term improvement in the present situation.

In past days when we needed fewer scientists and engineers, the high school science and mathematics teachers often could make very satisfactory predictions of the engineering potentiality among their students. With the increased numbers applying for entrance to our engineering schools today, the practical limits in accommodating them, and the serious shortage of secondary school science and mathematics teachers, other means of identifying promising prospective engineering students are extremely important.

My friends in administrative positions in the engineering schools have pointed out many instances within their experience of the lack of dependence they could place on secondary school grades as indi-

* Presented at the Annual Meeting of ASEE, Aeronautical Division, Penn State University, June 22, 1955.

cators of potentiality for the study of engineering.

A few weeks ago, I was asked by the officials of one of our service academies to check the score of a man who was in college but who had applied to that academy for admission as a regular beginning student. This man was reported to have earned A grades both in high school and in college, but his aptitude score on the service academy entrance examination was in the lowest 2% of applicants, the majority of whom were high school seniors. As many of you know, grading standards vary widely, high school curricula vary a great deal, and the ability level of the students in high schools varies widely. You many not be aware, however, of the extraordinary range of the ability differences between schools.

I know of one school in which the ability level of all of their ablest seniors is in the lowest third of the ability level of seniors in another school. I am told that in certain studies which Educational Testing Service has made there are some high schools in which almost all of the 50 or more graduates are lower in level of ability than the *least* able graduate in certain other high schools. My conversations in the last few years with several engineering administrators suggest that there may be more than an ordinary proportion of applicants in recent years who have rather high ability as indicated by the better ability tests such as the College Entrance Examination Board Scholastic Aptitude Test (particularly the mathematical score) and the Pre-Engineering Ability Test but whose weak motivation to study engineering is markedly reduced by their experiences in the first semester or first term when they learn that they really have to study and apply themselves. We are all familiar with the long-standing situation that a number of able students, at least in certain high schools, have coasted through their last few years of work picking up atrocious study habits and then were not able to develop good ones quite soon enough to remain in engineering college.

We do know that the mathematical score on the College Board Scholastic Aptitude Test provides a most effective prediction of engineering college grades. It is, of course, merely an indication of ability. It provides no clue as to achievement or to motivation. We have no evidence that it is a measure of talent for making money, or of persuasive skill in dealing with people, or of the ability to invent useful things. In addition to scholastic ability, we would like to learn whether an applicant has learned to study or to discipline himself to do the day to day work which will be assigned to him in engineering school, for often an exceptionally able freshman has not learned these things. Achievement test scores are partial clues in this connection as are grades in secondary school.

If we set our standard as the earning of satisfactory grades in engineering school, we can predict this standard rather well using existing psychological tests together with rank in high school class. The present evidence suggests that for almost all engineering schools the Scholastic Aptitude Test mathematics score alone is a somewhat better predictor of engineering grades than is rank in high school graduating class. A marked improvement occurs when we combine the Scholastic Aptitude Test mathematics score with rank in high school class (See Figure 1). A slight improvement results when, in addition to these, the Intermediate or the Advanced Mathematics Test score of the College Board is added into the composite of the mathematics Scholastic Aptitude Test score and rank in high school class. Many engineering schools have concluded that the additional advantage from use of the achievement tests is not worth the additional cost in terms of time and money to the applicant.

It is becoming increasingly widely known that the verbal score on the Scholastic Aptitude Test can be an important aid in evaluating the qualifications of a

FIGURE 1

MATHEMATICS TEST SCORES COMBINED WITH HIGH SCHOOL GRADES GIVE EXCELLENT PREDICTION OF ENGINEERING COLLEGE GRADES

Portion of class on high school grades or test scores combined with high school grades	Approximate odds that a student will earn average or better first-term grades in engineering for:	
	High school grades used alone	SAT–M* scores combined with high school grades
Highest 10%	4 to 1	11 to 1
Highest 25%	3 to 1	5 to 1
Lowest 25%	1 to 3	1 to 5
Lowest 10%	1 to 4	1 to 11

* The Scholastic Aptitude Test (Mathematical Section) of the College Entrance Examination Board.

Data based upon a study by Dr. W. B. Schrader for 721 enrolled engineering freshmen tested in the Fall of 1948 at Carnegie Institute of Technology, Cornell University, Lehigh University, Rutgers University, and the University of Pennsylvania.

The weighted average correlation coefficient of high school grades against first-term engineering grades at these five institutions was .46. The weighted average correlation coefficient of SAT–M scores combined with high school grades against first-term engineering grades for these five institutions was .66.

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high school senior who is an applicant to an engineering college. In general, we are recommending the use of a combined scholastic aptitude test score along with consideration of rank in high school class for predicting success in engineering college. This combined score may be either an average of the mathematics and verbal scores of the College Board Scholastic Aptitude Test or a total obtained by doubling the mathematics score and adding the verbal score so that in effect twice as much weight is given to the mathematics score. In this way, if the verbal score is low it will serve to depress either the average or the total composite score. Ideally, of course, the proper weighting would be worked out at each institution, for I know one in the middle-Atlantic area in which the verbal score is a slightly better predictor than the mathematics score. As far as I know this institution is the only exception to the general rule of better prediction by the mathematics score.

For those institutions which receive achievement test scores as well as aptitude test scores the comparison of achievement test scores against corresponding aptitude test scores may give a rather good clue as to whether a particular man has performed up to the level of his ability as measured by the aptitude test. If your institution makes use of the College Board scores, you may wish to see the second edition of *College Board Scores—Their Interpretation and Use*. This booklet should be a great help in the use of College Board scores. A recent article by John R. Valley of ETS on use of the College Board tests at Case Institute of Technology entitled "The Case Against Freshman Flunk-Outs" appeared in the Winter 1955 issue of the *College Board Review*.

Some engineering colleges are faced with a problem of high school students dropping in and asking for an immediate evaluation of their potential for the study of engineering. In such situations, the Pre-Engineering Ability Test can be a

very useful substitute for the College Board test scores. Some comparative data are available for the direct comparison on an approximate basis of the Pre-Engineering Ability Test scores to College Board Scholastic Aptitude Test mathematics scores.

Neither the College Entrance Examination Board Scholastic Aptitude Test nor the Pre-Engineering Ability Test is available for use by secondary school principals, deans, or counselors. However, the Cooperative Intermediate Algebra Test which is available for secondary school use, and which takes only 40 minutes of testing time in addition to some time for handing out and collecting the test papers, answer sheets, and electrographic pencils, has been found to be a very effective predictor of grades at two institutions, Purdue and Cornell, when given to incoming new high school graduates.

The Cooperative General Achievement Tests—Test 2, a test of general proficiency in the field of natural science, which takes 40 minutes, and Test 3, a test of general proficiency in the field of mathematics, which takes 40 minutes—have been found in several schools to be effective predictors of grades. All of the tests which I have mentioned, however, are designed for use primarily at the high school senior or 12th grade level.

I believe it to be extremely important for the welfare of this nation that more and more engineers working with the secondary school people in their local school districts recognize the importance of the early identification of prospective engineering students particularly at the 7th to 9th grade levels, the particular level depending upon local conditions. In the high school systems where junior high schools are the rule, the differentiation in curriculum of the college-going engineering and science-oriented student as compared with other college-going students and as compared with the non-college going students begins to occur often in the 7th or 8th grade. It is critical at this stage that more mathematically and scientifically oriented students be identified so that they can be guided into the appropriate sequences of mathematics, science, and English to prepare them to meet the admissions requirements of most engineering colleges. Repeatedly we hear of able prospective engineering students who learn in the 10th or 11th grade that they should have begun back at the 8th or 9th grade level to take the sequence of mathematics, science, and English that they needed to enter the enginering college of their choice. The Cooperative Mathematics Test for grades 7, 8, and 9 and the Cooperative Science Test for grades 7, 8, and 9 though sometimes too difficult for average students in the 7th and 8th grade can prove quite useful as indicators of promise for the study of engineering or science. At this level, many schools use the traditional I.Q. or intelligence test which has considerable merit but which properly requires the use of some indication of the student's interest in the area of science rather than in humanities or the social studies as a satisfactory clue to his promise as an engineering or science student.

If you were to study what happens in terms of college-going or non-college-going in the ablest 10 to 15% of high school graduates in many communities, you would most likely discover that about one-third of this ablest group do not go on to college at all. This happens for any one of a number of reasons which appear to be largely motivational and related to lack of encouragement by parents, teachers, older friends, or friends of their own age.

Some years ago when I was counseling students at Purdue University, I was amazed to find one very able freshman who told me that he had never thought about going to college until he had taken the Navy College Aptitude Test and discovered that he had a very high score and that the Navy, through its NROTC program, would pay his way through college. Three things are significant here: (1)

that he had not realized that he had the ability to do excellent college work; (2) he had not initially been motivated to go to college; and (3) the fact that he was alerted through the NROTC selection program. When he found that he had excellent college potential, and was simultaneously given an opportunity to finance his way to college, these circumstances created enough interest to make him go to college. It is obvious that engineering and science cannot claim all of this ablest one-third of the top ten to 15% who do not go on to college. If we were able to run aggressive campaigns in this country to identify prospective engineering, science, and other college-going talent, engineering would properly have to be satisfied with its own share but yet like the other groups mentioned would benefit by an increased number of able applicants.

To my mind, this problem of the early identification and the adequate utilization both in high school and in college of prospective engineering talent is of major importance to the nation's future. The engineering profession, secondary schools, and industry can, if they work together, discover and utilize far more effectively than we do today increasing numbers of qualified prospective engineering students.

For those of you who would find them of interest, I suggest reading two pamphlets developed from drafts I prepared several years ago which are receiving wide acceptance from secondary schools and engineering colleges. One of these is called "Secondary School Guidance Memorandum—Engineering" and the other "Tests for the Selection of Engineering Students." These are available without charge upon request to Educational Testing Service, Princeton, N. J.

College Notes

To stimulate further development of electronic devices for healing the sick, Hewlett-Packard Company of Palo Alto has established a $2,000 Medical Electronics Fellowship at **Stanford University's** School of Engineering. The Hewlett-Packard fellowship is intended for a graduate student whose major interest is electronics, but who is also interested in medicine and biology. It thus permits him to study for an advanced degree in electronics, with additional subjects in chemistry, biology, and medicine.

Mrs. Lois G. McDowell, assistant professor of mechanical engineering at **Illinois Institute of Technology**, has been elected national president of the Society of Women Engineers for 1955–56. The Society of Women Engineers is the national professional organization of graduate women engineers and women with equivalent engineering experience. Incorporated in 1952, the society has sections in 18 cities and three student chapters.

Professional Engineering Ethics in Practice*

By KENNETH A. MEADE

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Ethics has been described—rather facetiously—as "something that is good for the other fellow." Webster defines it in one way as "the science of moral duty; broadly, the science of ideal human character." As applied to a specific segment of people, or to a professional group, it is often defined as a "system or code of standards."

Physically, man's vision is limited by the function of his two eyes—which permit only a restricted forward view. But if man had a third eye—an inward view, so to speak—that would enable him to see himself as others see him—the task of devising and living by a system or code of standards would be enormously simplified. Such a vision would enable him to penetrate much deeper into his actions and show what is in his mind and heart.

Since ethics implies moral duty and responsibility, its foundation is something which lies much deeper within each of us than merely human eyes can see—although, to be sure, the results of a man's ethics are often painfully visible. The gunman who points a pistol at our hearts and demands our money or our lives cannot and does not want to conceal the terror of his weapon.

By the same token, man's ethical actions can be inspiringly apparent. The policeman who disregards his own safety and welfare while apprehending a gunman—or would-be assassin—is courageously displaying an obedience to moral duty. He is living up to the standards or code of his calling.

Here both the gunman and the police officer are acting according to their own acceptance or rejection of a code of ethical standards. And while their actions are visible—that which *motivated* each to act as he did lies within himself and is not visible. For while man is by nature basically good, he has, nevertheless, the freedom to choose between good and evil. Consequently, his actions are seldom entirely good or entirely bad. One of the functions of any code or standard is to remind him of the good and keep him steadfast in his free election to make his actions conform to the good.

Because of their precise and quantitative habits of thinking, scientists and engineers often find it difficult—when considering ethics—to understand or appreciate the inward patterns that lead men to behave as they do—that lead men to select the lesser good—and in some instances, the evil. We are able to detect the minutest flaw in the metallurgical structure of a huge flywheel by means of modern instrumentation; we are able to detect the slightest impurity in a metal by chemical and spectrographic tests; we are able, by selection, analysis and synthesis, to obtain purity in most material things. Yet, it is impossible to detect, much less predict, the purity of man's inward reasons for acting in an ethical or unethical fashion. We have yet to discover an instrument that will detect those inward motivations and subtle nuances of character that prompt men to deviate from the right and the acceptable.

* Presented at the Annual Meeting of ASEE, ECAC Conference on Professional Development, Penn State University, June 23, 1955.

Because this is true, we then must rely for our judgments of others on the limited basis of outward, visible evidence. We never know with absolute certainty that when our neighbor says "Good Morning" to us that he really means it. Or that the words used in a particularly glowing letter of congratulation necessarily express the writer's sincere feelings. But we can admire each for the gesture.

It is impossible to attach a positive or quantitative value to the ethical actions of people in general—or of engineers in particular. Every person has his or her own personal set of values—and these are largely determined by such factors as the individual's religious and social conscience, experience and environment.

But it is possible to provide both the individual and the group with a code or canon based upon sound moral and ethical principles that can serve to remind them of their responsibility and help them to achieve the highest possible degree of personal and professional integrity.

I have studied the 1953 report of The Committee on the Promotion of Ethical Standards (now the Committee on Ethics) of the American Society for Engineering Education, headed by C. J. Freund, Dean of Engineering at the University of Detroit. It was an excellent study which reached ten conclusions and made four recommendations. I should like to dwell for a moment on conclusions No. 2 and No. 7, which were:

(2) Engineers have an excellent reputation for integrity with the general public.

(7) Criteria exist for both general and professional ethics.

That engineers have an excellent reputation for integrity with the general public is not an accident. It occurs to me that we should with one hand pass a bouquet to the profession at large for establishing and enforcing a self-imposed standard of behavior and to the engineering educators who have been responsible for impressing the importance of these standards on their students. With the other we should present an ethical scale whereby today's engineers may continue to weigh their standards so that the same favorable things can be said of them in the future.

What would be the nature of this scale of ethics which we might hand to today's engineers? Dean Freund's committee considered several approaches for arriving at an evaluation of ethical professional conduct. They considered several criteria—the golden rule, the natural law, tradition, and religious teachings—before concluding that "any general system of ethics must rest upon more than one criterion or authority." Since many of the concepts involved in the criteria mentioned (and in any others which might be considered) are abstract, the contemplation of an ethical scale by the engineer, who is used to thinking in concrete terms, is not an easy task—quantities, mathematical formulae and measurable dimensions are his forte.

However, because engineers do have an excellent reputation for personal and professional integrity in the opinion of the general public, it must follow that whatever system is now being used to maintain these high ethical standards is a worthy one. The standards set down in the "Faith of the Engineer" and the "Canon of Ethics for Engineers," adopted by the Engineers Council for Professional Development, are firmly rooted in the principles of ethical conduct. To quote from the foreword of the latter, "as the keystone of professional conduct is integrity, the engineer will discharge his duties with fidelity to the public, his employers, and with fairness and impartiality to all." The principles and maxims contained in both these documents have helped to inspire responsible attitudes and foster an environment that has resulted in very high standards of professional integrity.

Environmental Condition

Perhaps it might be well, then, to examine the environmental condition under

which engineers work. Every engineer, of course, contributes to his own environment because he is by profession one who deals with those material and force relationships that surround us. It is needless here to recount his importance to society except to point out that, in number, engineers represent only a fraction of a per cent of our total population of about 165,000,000. This importance is reflected in practically every man-made thing which we own, borrow, or use. Without their contributions, both our national security and our increasing standard of living would be seriously jeopardized. They are by the nature of their profession called on to assume an important role at all levels of our society wherever they may work. Because of this, each engineer contributes largely to the shaping of his environment and of the environment of those around him.

I represent an industrial organization which employs a significant number of engineers. We have some 9000 graduate engineers at work in more than one hundred locations and, because of the diversity of our products and our decentralized operations, the environment of individual engineering groups probably differs in detail—but not in overall perspective.

In our organization, there is no special environment provided for engineers that is different from that for other employes. Rather, there is a common climate for all, regardless of the type of work done or the individuals involved. This working climate, or environment, is outlined in six basic principles that serve as a guide to all those responsible for the management of the business. They are also brought to the attention of every employee in the company as a guide in discharging individual and collective responsibilities.

These principles are:

(*1*) *Put the right people in the right places.*

In the case of the engineering graduate, this implies that he will be given a working assignment which will enable him to develop himself vocationally along the path which he selected when he decided to study engineering, and eventually to make the maximum contribution of which he is capable to the business, to the profession and to himself.

(*2*) *Train everyone for the job to be done.*

On-the-job training and orientation programs are set up to assist him in developing his talents and skills to their utmost.

(*3*) *Make the organization a coordinated team.*

In none of these more than one hundred locations do engineers work as "ivory tower" specialists in splendid isolation. Each has a place to fill in an organization which is welded together by common goals and the individual engineer contributes but a part to the overall achievement. His work is communicated to others and becomes valuable only as others on the team take advantage of what the engineer is able to contribute—whether his work be on the drafting board, in a dynamometer room, in manufacturing process development, as a production supervisor, or whatever his assignment. However, the organization of the team and the evaluation of its work by management are such that individual initiative and individual recognition are encouraged.

(*4*) *Supply the right tools and the right conditions.*

Few engineers can be productive without the proper facilities with which to work. A few might make their maximum contribution with the aid of nothing more than their intellects—and perhaps a little paper and a few pencils; but, for the most part, today's industrial needs are so complex that a very large investment is needed per engineer to provide the necessary laboratory and other facilities required to do the job which will keep the customers satisfied. Most of our engineers are engaged in a simplifying busi-

ness—making the complex simple so that it can be useful. The facilities required to make a simple device for dimming headlamps, for example, are quite considerable.

(5) *Give security with opportunity, incentive, recognition.*

While each engineer must capitalize upon his own opportunities to progress, incentives are provided to stimulate him to develop the best that is in him. These incentives are in the form of recognition within his own group; recognition by those above him in the line of management within the organization; and recognition in the outside world through technical society and community work. There are also financial rewards in the form of merit increases in salary commensurate with his individual contribution and responsibility. This is an important incentive always.

(6) *Look ahead, plan ahead . . . for more and better things.*

Much of this function is the responsibility of the company's team of engineers and scientists engaged in research, styling, product development and production guided by top management.

There you have the six basic principles which create the climate for the individual engineer's conduct in one typical industrial organization. These principles are founded on the concept involved in establishing the decentralized plan of operation for the organization developed during the 1920's. Mr. Sloan in his book "The Adventures of a White Collar Worker" in explaining his concept of how such an organization should be established said, "Divide the organization into as many parts as consistently can be done; place in charge of each part the most capable executive that can be found; develop a system of coordination so that each part may strengthen each other part, thus not only welding all parts together in the common interests of a joint enterprise, but importantly, developing ability and initiative through the instrumentalities of responsibility and ambition; and developing men—giving them opportunity to exercise their talents both in their own interest as well as that of the business."

In the 1940's a statement of these basic principles that I have just outlined was adopted as a guide to be followed in the operation of the business. When Mr. Harlow H. Curtice became President of General Motors in 1953 he again emphasized the importance of these principles to the continuing success of the organization in establishing, developing, and maintaining the right working environment.

You have probably noted that all of these principles deal with people. You will further note that each one of these principles implies a two-way responsibility. The responsibility of the organization to provide the opportunity and incentive—and the responsibility of each employe to make use of these tools in his own development.

Most folks would agree that these principles, if all were applied at all times as intended, would provide an ideal climate for proper individual ethics. It would be an exaggeration to claim that in application all of these principles are perfectly applied or maintained in perfect balance at all times, but each is a goal which our people try to achieve. Since all people have human frailties which evidence themselves even above the most sincere efforts to avoid them, here and there a small storm cloud does sometimes develop which darkens this apparently utopian sky.

Now what can be done when something happens to becloud this utopian climate? What is management's responsibility in the development of an environment that will promote the maintenance of high professional and ethical standards? What is the employe's responsibility?

All sound business principles or policies take into account the equities of every person and part of the total operation.

When policies are sound, the equities of all are in proper balance. The returns for shareholders are equitable and the rewards to each member of the working organization, from the top manager to the newest employee, are in balance—according to each individual's contribution to the success of the business; the quality of the product and its price are balanced so that the customer's best interests are served; and in every other aspect the equities—as opposed to the wants and the desires—of every individual concerned are taken into account and satisfied.

Let us consider for a moment the problem of placing the young engineer on the job. Once he has obtained his basic education as an engineer, it is up to his employer to place him in a starting job which will afford him an opportunity to make use of his training and at the same time provide for his own self-development. Later in his own self-development, he may be led into fields of activity other than engineering in which his contributions are more beneficial to himself, to his company, and to society at large. In any case, the decision as to which is the best place for the man in the organization must be arrived at through mutual understanding. Proper placement remains a mutual concern throughout his years of employment.

Training is a dual responsibility. The company places the training opportunities before the employe, but the employe must use these to improve his "know how" and develop himself according to the opportunities which are provided by management and which he makes for himself as he progresses.

Personal Code of Ethics

The contribution of the individual engineer to the overall group objective depends to a large extent on his personal code of ethics. The Canon of Ethics and the Faith of the Engineer both emphasize the necessity of a favorable attitude on the part of the engineer toward his work and his responsibilities. They also stress his favorable attitudes toward people. In the final sense, if followed, the ethical code of the engineer will lead him to a more wholesome attitude toward life in general. If he looks upon work not as drudgery to be endured but as a means of bringing out his innermost values for his own benefit and, as importantly, for that of the people around him, he assures himself success which cannot be measured by any standards created by man. If he recognizes the equities of all his associates and looks upon those around him as both a responsibility and as sources from which he may draw help in his own work, he ennobles his stature as a man, the only creature on earth who can be creative for the good of his comrades. A primary responsibility of management in this team-forming and team-working process is to recognize and reward those who by their own self-development and initiative figuratively raise their heads above the crowd.

This point, recognizing the individual, is much broader than evaluating his potential or promotability. In the case of the engineer, it includes providing an outlet for him to communicate the non-confidential results of his work to other engineers and to those not directly concerned with his work. Here, we mean appropriate encouragement in the development of technical society presentations and papers for publication and in committee and community work. Recognition within the organization is important, but that from outside the organization also contributes to the engineer's sense of well-being and personal value.

The matter of providing tools is almost wholly an employer responsibility, but here the employe may be responsible in some measure for making the recommendations which will lead to the selection of the best facilities to help the team do its job better. At the same time he is importantly responsible for the continued maintenance of the effectiveness of these facilities and putting them to their best

use in his part of the engineering program of the organization.

Planning and doing the job which needs to be done—embraced in the sixth point—is one of the major responsibilities of the engineering organization and here ethical standards as applied to the equities of all concerned are of extreme importance.

Engineers have set a high standard of professional ethics. The integrity of their professional opinions and decisions has been outstanding. The results of these standards are evident in the magnificent sturdiness of a dam which holds back with certainty the pressure of a river. They are evident in the school bus loaded with gay and carefree children crossing a suspension bridge in absolute safety. They are evident in the sure ease with which a crane picks up its load of steel and moves it to another part of a manufacturing plant. They are evident in the mechanism which responds to the touch of the brake pedal in a speeding automobile. They are evident in the security of the pilot as he pulls his aircraft level after a power dive. In these and countless other examples, the engineer's professional knowledge applied with integrity adds to the benefit and security of us all.

In the conduct which men expect of each other for the betterment of the world, the engineer is measured in the same abstract units which are applied to men of all professions and callings. I am firmly convinced that no person—engineer or whatever his calling—can take the whole credit for his achievements or his contributions. His abilities were provided by his Creator and without some measure of Divine guidance his efforts would not reach their greatest possibilities. By the same token, man cannot devise or apply any code of ethics worthy of the name without the aid of some Power greater than himself. Whatever may be his inner character—*ethikos*, from the Greek—his actions and attitudes will record it to the pleasure or displeasure of his comrades and his God.

Summary

In summary, maintenance of a high level of ethics by and for the engineer is a matter of grave national concern. As valuable and sparkling as the engineer's contribution may be, it could tarnish and deteriorate unless given under a code of high ethical standards. Engineers by the very nature of their work affect the mode of living of all of us in more ways than almost any other group in our economy. Thus the engineer is a servant of all men. May this service always be given in the light of equity and justice. This places on every engineer the serious responsibility of doing his work and directing his life according to the highest professional and moral standards that men of the profession can establish and achieve. Thus the engineer can enjoy the ultimate in personal satisfaction from his job and the contribution he makes to the betterment of the world in which he lives.

In the words of a proverb: "Help thy brother's boat across, and lo! thine own has reached the shore."

Eastern Joint Computer Conference

The Eastern Joint Computer Conference will be held November 7 through 9 at the Hotel Statler, Boston, Mass. J. G. Brainerd, Director of the Moore School of Electrical Engineering of the University of Pennsylvania, will be the keynote speaker.

University Technical Writers and Editors*

By LISLE ROSE

University of Illinois

We technical writers and editors are concerned with our skills and our status. We have grown so fast in numbers and responsibility that what we thought we knew about ourselves needs reviewing. We have to take stock of our collective skills and look at our position. We also want to look ahead, decide what we wish our skills and status to be, and plan how to bring them to that point. We want to know where we are, to set goals, and to figure out routes.

People whom universities and colleges call editors are all over the lot. Their range of duties is about as great as you can get from differing local needs and traditions and from a wide though tight supply-market. Their origins too are varied. College technical editors have come from engineering, sales, advertising, public relations, the city desk, scholarly journals, English and other academic fields. Their present jobs may bear small relation to their past ones.

Now, as TWE members we do not care about the peculiarities of college setups and college folk. But from the great variety within the field of college editing and from the causes and effects of that variety we may learn some lessons of general import.

Perhaps I should have used charts and/or statistics to show the variety. I did begin a chart. It was to symbolize how the schools assign editorial (and related) duties and how widely the official and the real jobs often differ. The chart got Dali-esque. I also played with the notion of a frequency diagram. But such a diagram may go out of date fast. The basis of many current practices may well change soon. Partly because of TWE studies academic people will learn that, if Topsy cannot be born again, at least her growth can be directed by principles. As a group we school men are beginning to feel sharply the lack of such principles —first step toward developing them. And as we develop them, today's welter of practices should give way, not to sameness, but to a much-needed order.

First let's see what the welter is. For information on this—on current situations and practices—I'm in debt to fourteen university and college technical editors and ex-editors who gave details on eighteen schools differing in size, location, purposes and structure. I hope they are representative samples. Help has also come from deans, directors, teachers, research men, and a few technical-press editors.

Papers at previous TWE meetings have shown how great is the number of tasks performed by technical editors in government and industry. When it comes to the schools we have to say, "Raise you two." One reason is that editing done in technical colleges is not identical with technical editing. It includes more, because much of the administrative work in such schools, plus many of their external contacts, and even some of their research, are not technological yet yield editing jobs.

In one or another engineering college, editors do all the kinds of chores performed over a period of some centuries by both newspaper editors and scholarly

* Prepared for Spring Meeting of Technical Writers and Editors Association, May 12, 1955. Shortly afterwards, members were saddened to learn of the untimely death of Lisle Rose.

editors. Their work extends from discerning, or even implanting, a gleam in the author's eye, to and beyond seeing publications through the press.

This is to be expected. Likewise to be expected is the host of non-editorial jobs done by people who are labeled editors. Some of these jobs can be called editorial —preparing scripts for radio, TV, and movies and for demonstration-displays, advising the staff of a student magazine. But other jobs done by editors are not editorial at all, unless we follow Alice's motto. Another way to put it is this: when we talk about technical editing in our colleges and universities we have to talk also about publicity work and about two of its forks—advertising and public relations. Nor can we talk only about the personal performance of these functions. We must regard their supervision and administration as well. We have to talk about teaching; and this teaching ranges from individual "tutoring"—Markup Hopkins on one end of a blue pencil and a faculty or student writer on the other —to formal class instruction for professors, for novice researchers, for undergraduates.

We even have to talk about overall management, for in some schools the editor has ended up as a part of the college's management team. He is usually the communication specialist on the team, but he is not that only. He helps to plan and carry out policy concerning the curriculum, faculty promotions, the budget, etc., etc.

A related fact is that several academic people who are called editors bear other titles in addition.

Finally, in many schools we find certain editorial tasks assigned to people who are not technical editors by profession or name.

All this diversity cries for analysis. We have to start our analysis by sketching the factors that have influenced the schools in their hiring and use of communication specialists. These factors are essentially the same as in government and industry, but within the schools they take some special forms. And, of course, their weight varies from institution to institution.

One obvious factor has been the supply of money. In many schools this supply has been so small that editors have to double or quadruple in brass. Another obvious factor has been the supply of persons. Qualified editors, photographers, illustrators, and other needed personnel are hard to find even today; they were still harder to find twenty years ago, when many of today's setups were installed. Hence a number of square pegs in round holes. Hence, too, the rounding out of some square pegs and the squaring off of some round holes.

Differences in Institutional Structure

Nationwide, just as big a factor has been the nature of differences in institutional structure. Of course, structure changes somewhat with time—and not always rationally. Most engineering colleges once operated on a pretty rigid line-basis; the shift to line-and-staff (a shift which in some schools has partly been caused by the demand for and the supply of communication specialists) has been general but not, on the whole, very carefully planned.

By and large, independent engineering colleges have been slower than their "bound" counterparts to see the need for an editor or similar specialist. This has been so in both line and line-and-staff setups. On the other hand, many independents have been freer to hire and use communication specialists as they think best.

Regardless of whether an engineering college is a whole or a part, we have to consider its internal structure. In many schools there is a tug between specialization, above all between specialization in research, and stress on that kind of communication that is called teaching. To simplify (unduly) let's say that research specialization has tended, markedly in this era of research teams, to produce a de-

mand for technical editing and then a demand for enlarging the volume of editing but not the scope. Research specialization has also led to much routinizing of editorial procedures, a trend reinforced by federal contract work. Teaching-oriented schools, I think, tend to give editors more kinds of jobs and to play down routinization.

So far I have been talking about the official structure of schools. The real structure may of course be something quite different, for attitudes—which I believe have played an even larger part in the operation of schools than of industry or government—attitudes sometimes bulwark the official structure, sometimes crack it, and once in a while dynamite it. So the question whether a communication specialist shall be hired, and then the question what duties and powers he shall be allowed, may be decided less in terms of the organization chart than by the emotions of research specialists.

The attitudes of administrators are important also. A number of old-line engineering deans looked at communication as opposite and inferior to action. Slowly, they or their successors have come to realize that communication is an integral part of action—a gain for the editor.

Teachers' attitudes have had a more scattered effect. Many teachers are pretty individualistic and dislike any additions to the administrative scaffolding. In a school where there are a lot of men like this, an editor may have had to be smuggled into the organization and may never gain status that his work and powers deserve. Other teachers regard themselves as communication specialists and resent being guided in any talks or writeups, however strongly institutional, that they prepare—though they may not object to an editor's doing promotional material. In counterbalance, many faculties contain influential teachers who have analyzed communication thoroughly enough to realize that teaching is only one mode of communication and that technical editors have a place to fill.

Another internal factor has been the committee system. That system gets deans and teachers used to seeing quasi-administrative jobs done through part-time channels. As a result, in some schools an English Department member has moved from the chairmanship of the college's publication committee to a permanent publications post.

So far, I haven't used the word "concept." But it is clear that the official structure of an organization, and the attitudes related in diverse ways to the structure, theoretically and often practically rest upon concepts. Some of these concepts are ex post facto, devised to explain and perhaps to justify what has already been done.

Let's look at the divergent concepts of an editor's function that the technical schools consciously hold and then at some that we can find with the x-ray.

In several schools the functions are conceived on the basis of a descending series of dichotomies. To use plain English, we halve the apple, halve it again, and keep on slicing. The editor then is considered as dealing not with action but with communication; with verbal communication only, not with graphical or mixed; not with oral communication but with written; with institutional documents, not with an author's "personal" output (whenever the line may be drawn); with the "form" and not the "content" of documents (in whatever way form and content may be defined). An editor so circumstanced will perform one of the four jobs which Irving Rosenbarker has said all technical editors should perform; that is, he will help authors to communicate ideas. Even this task he may do poorly. And he will probably not do at all the other three jobs that Mr. Rosenbarker named: He will not improve publication scheduling; he will not broadly or permanently improve an author's abilities; he will not improve—he will probably impair—the relationship that we like to see between editors and authors.

Via Mr. Rosenbarker, we have just

moved over to another set of concepts that affect the technical editor's work and status. These concepts relate to a college's personal-contact philosophy. In most small schools, close touch between faculty and students is common and it tends to be carried over to intra-faculty behavior. Large institutions generally try for these goals, but don't always reach them. So the size of the school may influence the relationship between editor and writer. Of course, a college does not necessarily share the traits of its university. A small engineering school in a large university may have a friendly and intimate faculty. Even large engineering schools within large universities may seek and get a lot of genial face-to-face contact.

The concepts I have just been talking about, though pretty superficial, are as far as many colleges have gone in their thinking. But *we* can go further. We might do so through an approach that Drucker takes in his recent "The Practice of Management."

Basic Operations

Drucker finds five basic operations in the manager's job: Setting objectives, organizing, motivating and communicating, measuring, and developing people. These add up to managing the business, managing managers, and managing work and workers. We might note that Bob Hamlett's chart (Fig. 4) in his "Technical Writing Grows into New Profession" covers these three functions though not by name.

As to the first, colleges differ widely in their answer to the question, "What is the business, if any, that an editor should manage?" I've said that a few schools believe he should help manage the college's whole business. Others leave him virtually no business to manage at all—even the format of his publications and indeed the style book that is to be his bible are imposed on him by a dean, a director, project supervisors, or sponsoring agencies. In such a situation, the college has not yet realized that there is a difference between the *business* of editing and the *work* of editing. If an open or tacit distinction *is* drawn, the concept of the editor's business may not include calling on him for innovations; he may be expected only to do better what his predecessors have done well. In other words, he doesn't set objectives, he merely accepts them—with all that this implies about motivating other persons, developing them, and measuring them and their output.

When we consider Drucker's second function—managing managers—we again find much diversity. Assistant editors and/or editorial assistants may be treated as workers, or they may be given managerial authority. Technical illustrators and photographers are, I believe, more likely to be at least submanagers. Design specialists within an editorial organization are very likely to have managerial status.

Where to place authors within Drucker's scheme is a problem. Some authors, to repeat what I said in other words, want to consider themselves as the managers and the editorial staff as workers or even as flunkies. An equally grave mistake is made when the pendulum swings to the other end of the arc. In good organizations there is actually a constant shift of status—at least during face-to-face contacts—on the part of an editorial man and his author. Now one, now the other is teacher; now one, now the other is decision-maker. I don't need to labor the point, except to say that in the technical colleges the trickest situation usually arises when an editor feels that a manuscript or talk should have substantive changes. Many an author then feels that his professional competence is being questioned.

Another group that is hard to classify and deal with consists of reviewers of manuscripts submitted for publication. Paid reviewers cause little trouble. Unpaid colleagues of the author had best be treated as I have implied that authors themselves should be treated—essentially like co-managers pro tem.

When we discuss either the business or the work of editorship, we can't avoid talking of remedial, preventive, and constructive operations. Some schools, even today, think of editorial service as mainly remedial—the correction of authors' rhetorical errors. And these errors may be defined just as the most hidebound of 18th Century precisians would have defined them. There are other schools which, in order to replace dosing by prevention, set up conferences or classes for authors. There are still others whose formal teaching or whose use of "tutorship" is inspired by more positive considerations:

1. Instructing authors in documentation.
2. Instructing them in scientific logic and methodology.
3. Trying to make them collaborate more effectively with fellow faculty members.
4. Giving them a feeling for the institutional approach in their research and writing.
5. Trying to make them better practical psychologists—not only in their writing but in face-to-face contacts.
6. Trying to make them more well rounded social beings.
7. Trying to inculcate in them a humanistic attitude.

Let me move our telescope. While doing so, I shall borrow a lens from School of Education people. They talk of the child-centered school, the teacher-centered school, the subject-centered school. Let's think briefly of editing as person-centered, product-centered or process-centered.

Then let's divide persons into natural and artificial. First for natural persons.

Some college editing is done to suit authors. Their reaction is the basic yardstick. Plainly, the results can be good or bad; they generally are bad. But when "author-centered" means that the editor tactfully teaches his authors, then the results can be good.

Second, some editors try only to suit individual bosses; if Dean Jones or Project Director Smith likes a report, a manual, a bulletin, that is enough.

Third, a few editors try to suit mainly themselves. No comment.

Presumptive Readers

Of the natural persons on whom editing may be focused the most important are actual or presumptive readers. Most of us college editors know too little about these readers. We need to become more familiar with our customers, particularly when they are many and various. We need to make more market surveys than we do, and better ones.

To move from natural to artificial persons, let's note that some college editors are promoted or fired on the basis of institutional approval. An institution may or may not be personified in one man or a small group. Of course a number of institutions may be concerned with the editor's product—as an assembling agency, as an authorizing agency, a reviewing agency, an issuing agency, a using agency. In a few schools I know of, these institutions are one. An engineering department, for instance, may prepare a bulletin, review it, authorize it, determine at least the basic content and structure (even over the editor's objections), and measure the worth of the bulletin by the judgments of its own members.

What I mean by "product-centered" is a little vague, even to me. I'll use the term to denote operations that are governed mainly by mere bigness. "The more pages we put out the better we are." Each document or other end-product is treated as an isolated unit except in so far as it pads the statistics.

Sometimes this criterion is hard to distinguish from that used by the process-centered office. In such an office the god may be system or the god may be speed. Most commonly he is efficiency, defined in terms that would have suited Taylor. That is, the stress is on certain kinds of systematization, not for its own sake but as a means to saving time and money. Let me say that many college editorial staffs

might respect this god more than they do. It is only when he becomes an idol that he is dangerous.

Perhaps we should add a further category—craft-centered editing. When the craft is the focus of attention, editing may be done for a fairly few experts whom the editor regards as his peers and judges—and some of these experts are dead. The experts, living and dead, are conceived of as possessing a taste which is lacking in the other persons with whom the editor deals—authors, his bosses, the bulk of his readers. Just which craft is focused on will vary from editor to editor. It may be the craft of journalism, it may be rhetoric, it may be typographical design.

I think it is clear that not all the schools are sure whether editing is a set of techniques, a craft, an art, a science, a business, or that combination of the five which is a profession. Nor are they all sure whether it is desirable to leave paths open by which editors may move out into non-editorial fields. They are not clear either on some logically smaller but practically very important matters; for example, the relative stress they should place on economy of time as against a set of functions that many colleges emphasize—the editor's tutorial and teaching functions. Assuredly they are not in agreement as to the kind of training an editor should have before appointment and on the job. The big fight of course is over engineering as against "verbal" backgrounds. My graying verbalistic self and my graying compeers are probably a passing evolutionary phase. Perhaps we are the dinosaur. Perhaps we are the kangaroo, a holdover adapted to a special habitat. Perhaps we are the eohippus, whose descendants include the zebra, the Shetland pony, the Arabian, the Percheron.

That most technical editors in the colleges and universities are doing a fine job is a tribute to their innate abilities and conscientiousness, and a further proof of the fact that people with those traits serving under or with supervisors of good will and high intelligence will usually "get out the work."

All the same, collectively we need a firmer base for our operations. We in the colleges might well study with care the functions of the publications engineer as Hamlett has worked them out and charted them. We ought to see how adaptable his and other systems are to our needs, philosophies, and ground rules. A study of Hamlett's and similar charts might lead some schools to change their concepts of their needs, to clarify their philosophies, and to rebuild the pitcher's mound and move the outfield fences. I know that I myself need to do these three things.

Management Audit Desirable

I think, too, that many of us college editors could profit from a management audit like that which the American Institute of Management makes for its members—an audit in terms of the subject-organization's

economic function
internal structure
health of growth
service to sponsors
development policies and their results
fiscal policies
operating efficiency
public service, and
executive (or personnel) evaluation.

I shudder to think what such an audit of my own office might reveal; and I ought to shudder.

Finally, all of us in technical writing and editing need more data—not only data about current practice but also attitude and opinion surveys. What do we think we ought to be doing, how, and with whom? What do other persons think? Which of these other persons matter to us? Many of us would be happy to see TWEA, as a national organization with an important social function, take steps toward planning for such surveys, analyzing and disseminating results, and thus contributing still further to our professional development.

Needs of Electric Power Industry for Nuclear Engineers*

By R. W. HARTWELL

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and

H. A. WAGNER

Assistant Manager of Engineering, The Detroit Edison Company

Introduction

To use nuclear energy for peaceful purposes is an expressed aim of not only this country, but of many of the European countries as well. One of the more important fields in which the peaceful use of nuclear energy appears feasible in the relatively near future is electrical power generation.

In discussing the need for nuclear engineers in the electric power industry, it may be pertinent to consider: (1) why the demand has suddenly become so great; (2) how many nuclear engineers will be needed and how soon; (3) how nuclear engineers will be utilized; (4) what capabilities these men should possess; and (5) what can be done to assist in fulfilling the need for engineers.

Increased Activity

The determination on the part of industry to carry forward the development of nuclear power plants was greatly reinforced by the passage of the Atomic Energy Act of 1954. Prior to that time, the inability to own reactor facilities as well as fissionable material limited the interest of private enterprise. Further, the policy of the U. S. Atomic Energy Commission to declassify more and more information, and to make it easier through "access agreements" for private enterprise to investigate and study the potential application of nuclear energy to their own business, has added greatly to the interest in atomic energy.

As an indication of the increased industrial interest in nuclear energy applications, it is observed that as of April 1954 there were eight study teams with Atomic Energy Commission agreements. These eight teams were investigating at their own expense the feasibility of producing economical electrical power with nuclear reactors. Some forty industrial and utility concerns were involved in this program. Today, one year later, twenty study teams consisting of more than 75 different industrial and utility concerns are actively involved in this AEC industrial participation program. Over fifty electric power systems are engaged in studying the feasibility of generating power by means of atomic energy.

It is significant to note that within the last three months, five independent groups have indicated a desire to build and operate nuclear power plants, four of which are in connection with the AEC Power Reactor Demonstration Program. The construction of these plants would be financed essentially with private capital. There are 25 electric power systems represented in the four proposals for construction of atomic power plants now

* Presented at the 63rd Annual Meeting of ASEE, Atomic Energy Education Division, Penn State University, June 22, 1955.

awaiting action by the Atomic Energy Commission.

As an example of the very rapid growth of interest, one prominent manufacturer of coal and oil burning steam generating equipment used in the power industry formed an atomic energy division in 1953 and assigned four men to work in this new group. In 1954 there were about one hundred engineers and scientists in the division, and by the end of 1955 it seems likely that the division will require the services of more than two hundred nuclear engineers. In most cases, these engineers are specialists in their fields and have been brought into the division from the outside. This growth is taking place in many companies in the electrical industry each month. The pattern seems to be to assign a capable engineering executive the responsibility of reviewing the general field of nuclear engineering to determine what attitude the particular company should take. Usually, this survey results in more extensive application studies and finally actual production in the new field. As each step in this progression is taken, additional specially trained engineering personnel are required.

Estimated Requirements

The need for nuclear engineers in the electric power industry will exceed the supply for the next ten years and possibly for an even longer period of time. This shortage of specially trained engineering personnel will be felt by the manufacturers of electrical power equipment and suppliers, the constructors and erectors of nuclear power plants, and the owners and operators of these new facilities.

The Detroit Edison Company has about 11,000 employes, of whom approximately 750 are graduate engineers. To provide for retirements, for replacements, and for growth, it is our practice to employ 30 to 35 engineering graduates each year. As atomic power plants take a more important part in the new capacity which will be installed, a portion of these graduates should have a nuclear background to enable us to design and operate nuclear plants.

In a recent survey of the atomic industry,† it is estimated that private industry engaged in atomic business will require approximately 3800 scientific and engineering personnel by 1958. The 20,000 engineering graduates available this June will not satisfy the needs of present industry, to say nothing of the expanding requirements of a rapidly growing new enterprise. If the atomic energy program in this country does not move forward as rapidly as now seems possible, one of the primary factors acting to retard progress will be the shortage of trained personnel.

Utilization of Nuclear Engineers

To avoid misunderstanding, it is important that we define what is meant by the term "nuclear engineering." In the broad sense, nuclear engineering is involved in the design, construction, testing, and operation of components and equipment that make use of nuclear processes and materials, as well as in the research and development pertaining to such use. For the electrical power industry, the nuclear engineer is primarily involved with the nuclear reactor and the handling of fissionable materials. A nuclear engineer should have a good background in the fundamentals of engineering, plus a working understanding of nuclear physics and chemistry, and their relation to practical problems.

Since the procurement of full-fledged nuclear engineers appears to pose a considerable problem in the near future, let us consider how the nuclear engineer will be used and what some of his qualifications should be, since this may enable use of engineers now on hand.

After management of an electric power system determines the need for a new conventional power plant and before this plant goes into service, some two to three years later, certain definite engineering

† Growth Survey of the Atomic Industry, 1955–65, Atomic Industrial Forum, Inc., April 1955.

steps must be taken. These steps include conceptual design, final design, specification preparation, equipment procurement, construction and erection, and finally personnel training and operation. While there are some systems which perform all of these functions, many electric power systems engage the services of engineering and construction firms to do various parts of the over-all job. It is for this reason that the size and function of the engineering departments in various power systems are so different today. There is every reason to believe that, as nuclear power plants are designed and built, some operating systems will do more of the over-all job than will others. From an over-all industry standpoint, however, all of the foregoing functions must be performed in building nuclear plants, and the man power must be made available either within the design group of the power system, or in the engineering organization servicing the power system.

In this review, it may be helpful to study the background of the men in the engineering group which has been assembled to carry out the conceptual design and specification preparation for a fast breeder reactor plant. These men are in the working group of the Atomic Power Development Associates, Inc., located in the General Offices of The Detroit Edison Company. This rather unique corporation, which includes thirty-three member companies, is the outgrowth of the Dow Chemical-Detroit Edison industrial study team. Preliminary work was started by this team late in 1950 and continued under an AEC contract in 1951. Since that time the group has grown until now there are twenty-five electric power systems represented in APDA, as well as four manufacturing enterprises, and four engineering organizations.

This project is engaged in the design of a liquid-metal-cooled fast breeder reactor which appears to have real promise for commercial success. Thus far, approximately $4 million, provided by the participating companies, has been spent for the effort, and a work program estimated to cost $3.8 million is planned for this year. The project has not set up a large laboratory, but rather has carried on research and development projects through the efforts of more than fifteen contractors. The corollary effect of engaging in the atomic power business is illustrated by this case. Not only is assistance needed in the direct plant design, but the research and development effort needed to make atomic power truly competitive will require the assistance of many engineers and scientists working in laboratories and elsewhere having no direct contact with power generation per se.

Qualifications

Each of the fifty-one engineers and scientists in the APDA working group has either been made available to the project by one of the member companies or has been hired from the outside on the APDA payroll. Figure 1 shows the organization chart for the APDA working group. Each section has been set up to perform a specific function. The following brief descriptions of some of the section responsibilities will also serve to indicate the type of engineers and scientists needed:

a. *Physics Section*

Reactor physics calculations concerning reactivity changes, material activation, nuclear performance, critical mass, and others are made by this section. Included in the work is the design of a reactor shield to protect personnel and equipment from nuclear radiation. A strong nuclear physics training is indicated, but an appreciation of engineering principles and economics is desirable, even though rarely found.

b. *Fuel Element Section*

The removable portions of the reactor, wherein most of the total reactor heat output is generated, are called fuel elements. The complete design of these

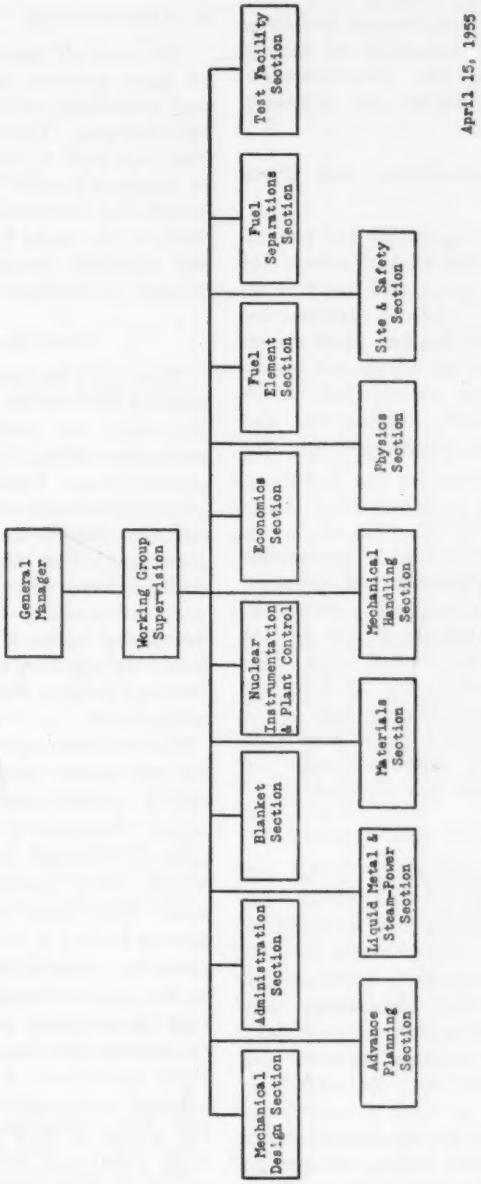
ATOMIC POWER DEVELOPMENT ASSOCIATES, INC.
ORGANIZATION
General Manager
Working Group Supervision
Mechanical Design Section
Administration Section
Blanket Section
Nuclear Instrumentation & Plant Control
Economics Section
Fuel Element Section
Fuel Separations Section
Test Facility Section
Advance Planning Section
Liquid Metal & Steam-Power Section
Materials Section
Mechanical Handling Section
Physics Section
Site & Safety Section
April 15, 1955

FIGURE 1.

fuel elements is the responsibility of this section. In evaluating design possibilities, these engineers must consider heat transfer characteristics, metallurgical and stress problems, and the economics of various manufacturing processes. Mechanical engineers and metallurgists are primarily required.

c. *Nuclear Instrumentation and Plant Control*

This section is responsible for providing a safe and stable control system for the entire nuclear plant and has full responsibility for all controls, instrumentation and devices which affect plant operation. This includes the design and operation of the reactor control rods which regulate power level. Mechanical and electrical engineers are needed for this work.

d. *Test Facility Section*

The test facility section is responsible for the design, construction and operation of a nonradioactive test facility which will be a full-scale prototype of the reactor with one liquid metal coolant loop. This facility will be used to test final reactor components and assemblies as well as for the training of reactor plant personnel. Engineers familiar with research and operating procedures are required.

e. *Fuel Processing*

The primary responsibility of this section is the development of processes for chemical and metallurgical treatment of irradiated reactor fuels. This involves the separation of uranium, plutonium, and fission products so that the uranium may be recycled in the reactor as new fuel. The plutonium is suitable for sale, and the fission products may be stored or possibly sold.

In addition to the process determination and separations plant design, this section has responsibility for fissionable materials transfer, storage and shipping facilities, the radio-chemical laboratories, and radioactive waste treatment and disposal. This work requires the efforts of chemical and metallurgical engineers.

f. *Administration*

The over-all successful accomplishment of these projects requires the leadership and organizing ability of engineering administrators. This is a highly technical field in a state of great change. The need is nowhere greater for able engineers to secure the cooperation and guide the efforts of the many types of engineers and the scientists required to bring such a project to fruition.

Basic Requirements

There may be some misconceptions concerning the number of highly theoretical physicists and mathematicians that are needed to design, test and build a power reactor plant. Basic reactor design work and performance calculations must be accurately done by such specially trained personnel. For this work, the physicist, mathematician or engineer draws on many years of academic training and possibly five to ten years of work in the nuclear field. It appears that only a relatively few on a project such as ours require this background.

Most of the engineers engaged in reactor and reactor component design require only a limited knowledge of nuclear concepts. Familiarity with the terminology must be obtained by an engineer before he can really contribute in the nuclear field. It has been our experience that engineers having a good background of engineering training and a sincere interest in the nuclear business can and will obtain an adequate working knowledge of the nuclear physics needed in a comparatively short time. A summary of the educational background of the APDA working group is shown in Figure 2. The large number of mechanical engineers involved in fitting the fast breeder reactor and its various systems together is always surprising. Many of these engineers concentrate on "hardware" type problems

FIGURE 2

EDUCATIONAL BACKGROUND OF APDA WORKING GROUP PERSONNEL

	B.S.	M.S.	Ph.D.	ORSORT*	Total
Chemical Engineers	3	1	–	–	4
Civil Engineers	1	–	–	–	1
Mechanical Engineers	20	3	1	(1)	24
Electrical Engineers	4	2	–	(2)	6
Metallurgical Engineers	2	1	–	–	3
Physicists	2	4	1	(1)	7
Physical Chemists	–	1	1	–	2
Mathematicians	–	1	–	–	1
Lawyers—LLB					1
Administrative Personnel					2
					51

* Oak Ridge School of Reactor Technology.

which are absolutely vital to the operation of the reactor plant.

Special requirements of a reactor system may have a pronounced effect on the design of pumps, valves, fittings, insulation, piping and heat exchangers. This is surely the case in a liquid-metal-cooled reactor system where very large quantities of molten sodium and sodium-potassium alloy must be circulated. Likewise, it is the case where reactors are cooled with very high pressure water which must be maintained in a completely clean, virtually leak-tight stainless steel system. These special design problems are solved by capable mechanical and metallurgical engineers who at the same time understand the general requirements of nuclear processes.

Satisfying the Needs

In attempting to meet the demand for engineers in the nuclear field, it would appear that three principal courses should be helpful.

1. Every possible assistance and encouragement should be given to our engineering colleges and universities to enable them to provide the training needed. In our opinion, this can best be accomplished by adding to the established engineering curriculum, possibly in the form of graduate work. The basic engineering training should not be sacrificed in favor of nuclear subjects, since by far the larger part of the design is concerned with basic engineering.

The training provided by the AEC through the schools at Oak Ridge and Argonne National Laboratory has been of tremendous value to those engaging in the study of nuclear power. Also, the Atomic Energy Commission's willingness to permit engineers from industry to work in AEC contractors' facilities has been most helpful.

2. Research and engineering projects may be placed in universities to enable them to provide training to personnel already on hand. Direct contact with the practical problems which arise in utilizing atomic energy will serve to supplement the principles which have been learned in the classroom. As an illustration, APDA, Inc. has a contract with the University of Michigan to study and evaluate certain phases of chemical and metallurgical reprocessing; with Rensselaer Polytechnic Institute to develop a scrap recovery system; with the Battelle Memorial Institute to study improved methods of making fuel elements; and others. APDA has also made arrangements with the Institute for

FIGURE 3

CASE HISTORIES—ACADEMIC AND TRAINING BACKGROUND

Engineer	Section	Age	Formal Academic Training	Additional Training	Employed by	Period of Employment Prior to Reporting to APDA, Inc.	Duties Prior to Reporting to APDA, Inc.	Years with APDA
A	Fuel Element	29	BS-ME 1948 MS-ME 1949	Instructor during last 2 years in school; also work on research project	Electric Power System	3 Years	Power Plant Design	2
B	Physics	30	B-ME 1949 ORSORT 1951	Completed 9 hours of graduate work	Electric Power System	4 years	System Operation	3
C	Mechanical Handling	43	BS-EE 1934 BS-Phy 1950 MS-Phy 1954	Took special courses in reactor theory during 1953–54	Electric Power System	20 Years including 3 years on loan to G.E. Co. (KAPL)	Power Plant Design	1
D	Instrumentation and Control	35	BS-EE 1949 ORSORT 1951	Took 20 hours of graduate work prior to going to ORSORT and has taken 10 hours since 1951	Electrical Manufacturing Enterprise	4 Years	Electrical Equipment Design	2

Atomic Research (Iowa State College) to study fission product separation.

3. We have found it to be entirely feasible to train engineers already at hand in the special knowledge needed for nuclear work. While this does not lessen the need for engineers in a company, it will provide the specialized training required now and until such time as this can be secured in the normal way in our universities.

The Detroit Edison Company has worked very closely with the Extension Division of the University of Michigan. During this past year, Dr. Henry J. Gomberg, Assistant Professor of Electrical Engineering and Assistant Director of the Phoenix Project, along with some assistants, presented extension courses in nuclear engineering in Detroit. These were very well received. When this training program was announced to Detroit Edison employes, it was thought that possibly 25–35 employes might be interested in this graduate course, Introduction to Nuclear Engineering. The course was described as follows:

> INTRODUCTION TO NUCLEAR ENGINEERING (Basic). An introductory treatment of application of theoretical physics in the production of nuclear energy, designed to develop a broad background in atomic and nuclear science. Text: *Introduction to Atomic and Nuclear Physics,* by Semat.

More than 150 Detroit Edison men signed up for this first course, but only 75 could be accepted during the fall semester. The course was repeated during the next semester and the second course—Nuclear Structure and Stability (Advanced)—was taken by about 40 employes. Of the 40 who took the second course, 18 have asked that the third semester's work be offered next fall.

An intensive desire to become knowledgeable in the new field of nuclear energy has been, of course, of tremendous assist-

ance in developing some of our electrical and mechanical engineers into nuclear engineers.

In this connection, it is of interest to study the academic and training backgrounds of four of the engineers holding positions of responsibility in the APDA group. Referring to Figure 1, we will select for this case history review the heads of the Fuel Element, Physics, Mechanical Design, and Instrumentation and Control Sections.

Analysis of the data presented in Figure 3 suggests that there are various ways of attaining competence in the field of nuclear engineering. Engineer A had no specialized training in the field prior to his joining APDA, while Engineers B and D attended the one-year course offered at the Oak Ridge School of Reactor Technology. Engineer C, some fifteen years out of school, developed an interest in physics and nuclear engineering. His additional schooling and the three years' experience at the Knolls Atomic Power Laboratory equipped him to perform his present duties very well.

Experience to be gained while on loan to one of the governmental laboratories is very valuable. Detroit Edison now has two engineers on loan to the Argonne National Laboratory. Another method of giving nuclear engineering training to men already established in the power engineering field is to offer scholarships. In this regard, Detroit Edison has an employe completing his master's degree in nuclear engineering at the University of Michigan and also has another taking a special seven-month course at Argonne National Laboratory.

Conclusion

In conclusion, we consider the peaceful utilization of atomic energy as one of the great new forces which will come into full use within the next two decades. An increasing part of new electrical capacity will be nuclear power, and new uses for what are now waste fission products will surely be found. This expanding industry will require an ever greater number of scientists and engineers to implement this program. We are confident that our colleges and universities working together with industry will meet this challenge successfully.

College Notes

The **New York University** College of Engineering has begun programs in nuclear engineering and engineering science this fall. The graduate nuclear engineering program, for which the degree of master of nuclear engineering has been authorized, is among the first in the United States. The engineering science program for undergraduates is directed primarily toward specialization in nuclear engineering.

In accordance with these new programs, a sub-critical nuclear reactor has been built with the Atomic Energy Commission's permission. This reactor, the first of its kind at a university, will be used for experiments in undergraduate and graduate laboratory classes in nuclear engineering. This reactor will be exhibited at the Atomic Energy Exhibition in connection with the Engineers Joint Council Congress on Nuclear Engineering to be held in Cleveland in December.

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
JOHN L. ARTLEY, *Chairman*
Duke University

Editor of YET-itudes
LEE HARRISBERGER
N. C. State College

Lookin' Ahead

The Committee on Young Engineering Teachers is appointed under new management by the General Council each June. This year the CYET has set up another healthy and worthwhile program of real interest and value to every "youngster" in the business.

John Artley is this year's "boss" and is assisted by Tom Boyle, Assistant Professor of Mechanical Engineering at Michigan, as Vice-Chairman, and Lee Harrisberger, Assistant Professor of Mechanical Engineering at North Carolina State. John is Assistant Professor of Electrical Engineering at Duke, has been teaching six years, worked in industry a year and a half, and boasts of his three children (and wife). Since John is the "wheel," we asked him what's gonna make the wheel roll and he sez:

"The groundwork for a year of effective effort by the CYET was laid by Phil Weinberg at the annual meeting last June. The following recommendations concerning our activities were unanimously accepted by the General Council. It was recommended:

- That the CYET sectional subchairmen be elected at sectional meetings by the general membership. This would lead to closer cooperation between section officers and the YET subchairmen. The details of implementing this recommendation must be worked out through the proper channels. Until this is done we will continue to make up the committee membership by the 'will-you-volunteer' method used in the past.
- That the CYET be delegated to assist the Society in its membership drive. I hope each YET will take it upon himself to increase the effective membership of the Society. Effective membership should mean something beside paid dues and having a name on the roll. It might be well to have less of a membership drive and more drive within the membership. As a YET you have an excuse for being enthusiastic and vigorous. Get out and wake up some of the old engineering teachers. It is also desirable to contact persons in the service courses (Physics, Math, English, etc.)

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."
YET-itudes! Not Platitudes!

and interest them in the job we are doing.

- That the paper contest for YETs be continued and that notification of the rules be sent to all section chairmen and CYET subchairmen by October 1, 1955 for early publicity. An early announcement of the paper contest rules should help the slow starters. Here is an opportunity to tell your colleagues what you are thinking and doing about getting better engineers in action. If you have any worthwhile thoughts let us hear about them. If we haven't anything worth telling, why are we in the teaching profession?
- That a short term summer school be planned by the Educational Methods Division and CYET to precede the convention on a theme stressing pedagogical methods. There is a concern for a need of knowledge of the pedagogical aspects of engineering teaching. In addition to the proper scientific knowledge an engineering teacher should be cognizant of good teaching techniques and methods. Ed Kraybill, of the Educational Methods Division, suggested cooperating in planning such a session. We will work with him in this area.
- That a committee be appointed to study the feasibility of establishing an annual summer workshop for Young Engineering Teachers. This last recommendation carries the seed to answering many problems in maintaining and advancing standards in engineering education. You will be hearing more about this in future 'YET-itudes.'

You will be notified as to the progress of action concerning these recommendations. In the meantime, if you have any thoughts concerning CYET and YETs let us hear from you. Nothing like writing a letter or a paper to broadcast a good idea or gripe.

Engineering Education presents one of the most interesting challenges in our society. As Young Engineering Teachers we will be increasingly involved in evolving a pattern of education which represents progress. A vital aspect in effective progress of this nature is the communication of ideas and information. The CYET is an organized means for channeling such information. Use it!" . . . John Artley Chairman, CYET.

There are some fine things in store for the YET this year and notable among them is the planning for the first summer workshop for YETs! This is certainly going to be a wonderful opportunity. If ASEE is to ever do a great thing for its younger members, it will have its chance here. There is no one who needs concentrated study of pedagogical problems more than the YET. And every conscientious YET is anxious to become involved in such activity.

We would like to drop a big hint to all engineering deans and department heads looking in on this article, to wit: The guys who need to go to the ASEE workshops and the national convention, above anyone else, are the young engineering teachers. But very few do! Because it costs too much to pay it out of the personal pocket and the YETs are the least able to pay.

We are plugging for some thoughtful and positive activity within engineering college administration to start NOW to plan some way of getting their most promising young teachers to the YET summer workshop and the ASEE convention next year. We feel that every department has an obligation to itself and the YET to provide an in-service training program to insure better teachers and keep them.

It certainly would be a sound investment to see to it that at least one or two YETs from each department were sent to the YET workshop each year. Industry takes our half-trained graduates and give them extensive on-the-job training to make good engineers out of them. But, ironically, we expect our un-trained young teachers to become great educators with

absolutely no on-the-job training and no encouragement.

Engineering schools should REQUIRE that every young engineering teacher attend the ASEE workshops and conventions. They should regard it as a duty to perpetuate the quality of the staff. We always provide funds to keep the labs up to date and progressive. Why shouldn't we likewise provide funds to keep the faculty up to date? It's an investment! It should not fall within the hazardous category of travel funds (there is no fund that takes a budget beating like the travel fund). It should fall in the category of capital expenditures for modernization of the staff.

Let's get behind this thing! You can not have a summer workshop for YETs if they are all too poor and unprovided for to attend! Start some planning at your school to arrive at ways and means to get at least one YET to the workshop. If every engineering school sent only one YET delegate, we would have over 150 in attendance. That would be a real successful deal!—Lee H.

Here's your YET-itude for October:

Get out the lead, Ned! Plead the need!

College Notes

Rear Admiral Robert S. Hatcher (Retired) has been appointed director of the Guggenheim School of Aeronautics at the **New York University College of Engineering.** He also was named chairman of the department of aeronautical engineering, with the rank of professor. Until his recent retirement after 31 years of active service, Admiral Hatcher was assistant chief of the Navy's Bureau of Aeronautics in charge of research and development.

Admiral Hatcher succeeds Professor Frederick K. Teichmann, who has headed the Guggenheim School since 1945. Professor Teichmann will devote full time to his duties as assistant dean in charge of the Day Division of the College of Engineering.

Charles R. Anderson of Tappan, N. Y., has been named Director of the Division of Science and Technology of the Evening School of **Pratt Institute.** His Division is one of the three forming the Evening School of Pratt Institute, which began separate existence on July 1 of this year. It was formerly operated in conjunction with the School of Engineering.

The Use of Computers in Handling Statistical Data*

By W. W. BAKER

Engineering Department, Carbide and Carbon Chemicals Company

Introduction

Computation has developed out of measuring and counting, the two sciences being called geometry and arithmetic, respectively. A thousand years ago, the development of the abacus overcame the limitation set by the inadequacy of the number of fingers and toes a man could produce. Finally, hundreds of years after the development of the abacus, and thousands of years after the beginning of counting and arithmetic, great minds produced the little cogs which grew into modern adding machines, desk calculators, and accounting machines.

During the past few years, most people have heard of the remarkable devices often called the electronic brains. Every school boy knows that there are in existence some very complicated machines which are capable of outstanding feats of arithmetic. Some of these machines are more clever than others—able to do more kinds of problems. Some can solve problems that men cannot solve in hundreds of years. There are people who even consider an electronic computing machine to be capable of thought.

A general purpose computer is only a tool, just as a staff of persons at desk calculators constitutes a tool. If it is assumed that a staff has only enough intelligence and responsibility to carry out the simplest instructions and make the simplest decisions concerning the sizes of numbers, then all problems must be prepared as simple steps to be executed in sequence. The type of analysis that would be required to instruct such a staff is the same type of problem analysis that is needed for instructing general purpose computers.

The principles of modern computing machines are not new, even though electronic computers have been in operation only 11 years. More than 140 years ago, Charles Babbage dreamed of a machine that would add, subtract, multiply, and divide. It would also perform, automatically and without human intervention, a predescribed sequence of arithmetic operations and make predescribed logical decisions based on the results as it went along. In outlining his analytical machine, Babbage described all of the principles of modern digital computers.

Since the end of World War II, a number of computers have become available to industry. The first of these were produced primarily for business purposes, but it was only natural that modifications and developments would be made to these business machines to make them more applicable to scientific and engineering calculations. In more recent years, new types of computing machines have been developed specifically for scientific work. The majority of these machines are of the digital type; however, the analogue machine is becoming more and more important.

Types of Computers

There are two general types of computing machines. The analogue computer is

* Presented at the Annual Meeting of ASEE, Chemical Division, Penn State University, June 24, 1955.

just what its name implies: a physical analogy to the type of problem its designer wishes to solve. Information is supplied to the machine in terms of the value of some physical quantity. The machine transforms this physical quantity in accordance with the rules of its construction. A typical example would be an electrical network used to simulate a complex pipeline distribution system. The current flow would be analogous to the fluid flow and the economics of changes in the distribution system may quickly be investigated.

In comparing digital and analogue machines for simple problems, the analogue machine is almost always less elaborate. Even the most elementary digital computer requires an arithmetical unit, a control unit, a storage unit, an input device for basic data and instructions, and an output device for interpretation of results. In contrast, an analogue machine need be no more complicated than the problem demands. A slide rule, for example, is a perfectly respectable information machine of the analogue type.

As the problems become more complex, the analogue machine loses its initial advantage. Since it is a physical analogy of the problem, the more complicated the problem, the more complex the machine must be. Random electrical disturbances always occur in electrical circuits, and in the more complex analogue machines, these disturbances have an adverse effect on the accuracy of the results. This places a practical limit on the complexity of an electrical analogue computer. The digital machine is entirely free of such hazards. There is no intrinsic limit on the complexity of the problem that the digital machine can perform or control.

The third important difference between analogue and digital machines is their accuracy potential. The precision of the analogue machine is restricted by the accuracy with which physical quantities can be handled and measured. It is not uncommon to speak of accuracies of 1 or 2 parts per 100, but in the more complex units the accuracy may be much less than this. This is one of the more limiting disadvantages that analogue computers have in the field of scientific computations. On the other hand, a digital machine which deals only with discrete numbers can be as precise as the problem demands. When a result has more digits than places in the counter in a machine, "rounding off" must be done even in a digital machine, but the usual thing is for the result to contain more digits than are needed.

There is yet a fourth respect in which the two machines differ. An analogue computer works in what is called "real time," that is, it continuously offers the solution to the problem that it is solving, and this solution is appropriate at every instant to all of the information which has so far entered the machine. This property of working in "real time" is very important in most problems of automatic control. Some of the modern digital machines can achieve the necessary speed to work in "real time" for the control of aircraft, but they are not fast enough to deal with the problem of simulating the flight performance of a guided missle.

In simple applications, in which no great precision is required, an analogue computer will usually be preferable. For complex problems, or problems in which a high degree of precision is required, a digital machine is superior. Where "real time" computations must be made, analogue machines are almost always used now, though digital machines are beginning to achieve speeds to fit them for this type of application.

It should be obvious from the foregoing discussion that a digital type of computer is the most desirable for statistical and engineering applications. For a machine to be called a computer it must have five basic components: input, output, control, arithmetic, and storage. Even a desk calculator has these five.

Input

Input methods for computing machines vary with manufacturers. The input to a desk calculator is by way of the keyboard. The most common input to the automatic machines is the punched card. This form of input is especially desirable for accounting and business work because a single card can obtain all the information necessary about a purchase order contract, a storeroom item, a magazine subscription, and other similar information. In addition, punched card systems are especially adaptable for payroll work and general accounting problems, and they can also be used for scientific calculations.

Basic data and instructions can be read into some computing machines from perforated paper tape or from magnetic tape. The information is originally placed on the tape by a device that is quite similar to a typewriter. A typed copy of the data and instructions is made at the same time they are placed on the tape. This facilitates proofreading and checking. Generally, the speed with which information can be read into machines from the paper tape or magnetic tape is considerably faster than the input from punched cards.

Storage

The capacity of the storage unit and the access time to obtain the data from storage has been a major limitation in digital computers. Mechanical counters, similar to those in desk calculators, were first used; but recent developments have made the use of magnetic drums, magnetic tapes, and electrostatic storage practical. The availability of more storage capacity has greatly widened the field of digital computers. In the most modern machines, all of the basic data and instructions can be stored in the machine. The program is written in such a manner that it can utilize this stored information effectively.

Control

A control unit of a digital computer varies in type and style with the different manufacturers. Generally speaking, the more complex and advanced computers are far easier to control than the slower machines. Just a few years ago, it was necessary to wire individual control panels for each separate problem. It is now possible to code or program a problem for a computer at some remote location because the machines have built-in arithmetic commands or else they use general purpose plug boards. Most machines use what is called the three-address code. The first two addresses give the location of the numbers to be operated on, and the third address tells the machine where to store the result. The list of commands varies with each manufacturer, but always included are all of the standard arithmetic commands: input and output commands, some special commands, and certain "logical" commands to enable the programer to unscramble the stored data.

Arithmetic

The arithmetic units of modern automatic computers are always eletronic in nature. These units are so much faster than the other elements of a computer that it is difficult to utilize the full speed potential of a machine. Even so, high speed solutions are vital in a rapidly changing economy; greater speeds for our calculators will probably always be desired.

Output

If the input to a computer is a punched card, the output may then be a punched card or a printed scroll. If the input is a paper tape or magnetic tape, the output may then be a printed scroll, another tape, or an array on a cathode ray tube.

Advantages

Automatic calculators are expensive, not only in initial cost or monthly rental, but in upkeep in terms of keeping them busy. A machine earns no return when

it stands idle; in the case of a giant machine which may carry out instructions at rates of a million a minute or more, the problem of keeping it fed with problems can necessitate a staff of around thirty highly skilled people. Is such expense justified? To put it another way, what advantages do we gain from using automatic machines?

The primary gain, of course, is speed. This not only means that we can get our problems solved rapidly (i.e., before the solution becomes meaningless), but in many cases it means that through high speed we have the only possible way to solve a problem at all.

There are more International Business Machines' Card-Programmed Electronic Calculators (CPC) in service than any other computer. These are not fast machines, but they perform the arithmetic for the inversion of a 20-order matrix in about 8 hours. A 10-order matrix requires about 3 hours. This is quite long compared to some machines, but the CPC has limited storage and an excess of card handling is necessary.

The IBM Magnetic Drum Calculator Type 650 is a more advanced machine than the CPC and can do the same inversion about 10 times faster than the CPC. This is the result of a greater internal storage capacity. The elements of the matrix can be stored on a magnetic drum, and the machine can proceed with the computations with little delay.

If a large-scale computer is available with virtually unlimited storage and nearly instant access to the stored data, the speeds are almost fantastic. As an example, one machine can invert a matrix of order 31 with an input time of 4 minutes for the instructions and data; a calculation time of 4 minutes; and an output time of 10 minutes. Another machine can invert a matrix of order 15 in 1.2 seconds with only 19 instructions.

Together with speed, we get accuracy from automatic machines. In many problems, a single number is used many times; once entered into the machine correctly, the machine can be expected to repeat it correctly. Present machines are not absolutely perfect in this respect, but are very nearly so; at the least, they avoid the common human errors of miscopying.

We also gain in precision through using automatic computers, simply because it is no "harder" for a machine to carry eight digits throughout a calculation than it is to carry five.

A further gain is made in economy. One company, International Business Machines, produces a full line of computers, ranging from a small electromechanical type of machine up to the giant electronic computers. To illustrate, it might be fair to figure the cost of a single typical arithmetic operation on a desk calculator in pennies (say $0.03).

The cost per operation on an IBM 602A or similar machine might then be one-tenth as much, or $0.003.

The cost per operation on an IBM Card-Programmed Calculator (CPC) could be represented by $0.0003.

The cost per operation on an IBM 704 or Univac Scientific might be around $0.00003. These figures are relative only, and all assume full usage of the machine involved.

Statistical Applications

Probably an entire book could be written about the use of automatic computing machines in the solution of problems of a statistical nature. In fact, wide use of electronic digital computers has led to a revision of statistical methods. Much of the theory of statistics is, almost by definition, the characterization of large quantities of numerical information by certain indexes, of which the most common are the average and mean-square deviation. If the data can be placed on cards or tape, the reduction to a few statistics is often unnecessary.

Automatic computers permit statistical investigations where the work involved in manual treatment is not justified because of the low probability of gaining anything significant. An example is correla-

tions of scanty data, where normally one would hesitate to subdivide the sample into all the suggested categories. If a computer is available, it may be possible to find a trend or pattern at an earlier stage of the investigation, and subsequent experiment design can be made more effective.

The end point of most statistical experiment designs is a set of correlation equations. It is in this field that computers have been the biggest aid to the statistician. To obtain the correlation coefficient, many arithmetic operations must be performed. This number depends on the number of variables in the experiment and the number of levels that were considered. The result involves matrix multiplication and matrix inversion.

To illustrate how much arithmetic is required, if N is the order of the matrix, then $(2N^3 + 3N^2 - 5N)/6 =$ the number of additions and multiplications and $[N(N+1)]/2 =$ the number of divisions required for the inversion. Therefore, the inversion of a 20-order matrix requires about 3060 arithmetic operations. Unless it is a special case in which several of the elements are zero, a 12-order matrix is about the upper limit for desk calculator solution, and this is extremely laborious.

Computing machines are useful to a certain degree for the most simple statistical problems such as squaring numbers and then taking the square root of the sum of the squares. This becomes most attractive when a tape-controlled machine is available because its input-output speed is usually superior and a greater time advantage can be realized.

Automatic computers have made it possible to solve problems in statistics that heretofore have been considered impossible. The widespread use of these machines has actually caused a serious shortage of mathematicians and statisticians because personnel with training in these fields are best equipped to use the machines to the fullest advantage. Furthermore, the field of statistics has developed and broadened so much in recent years that industrial management is finally willing to accept statistical methods as a guide to decision.

One of the main factors in the expansion of the fields of mathematics and statistics has been the development of electronic computers. These machines make it possible to do more statistical work, in less time, at a more reasonable cost, and with greater accuracy and precision than has ever before been possible.

In the News

Joseph F. Hardee, former instructor in engineering mechanics at North Carolina State College, has joined the staff of the **Esso Research and Engineering Co.**

Cooperative Engineering Calendars*

By DONALD C. HUNT

Director of Coordination and Placement, University of Detroit

Continued progress and development for fifty years with tremendous strides in the past two decades is the history of cooperative engineering education. Indicative of this development is the growing recognition among industrialists that cooperative training provides an answer to the need for well adjusted and properly oriented engineers who can step into positions of responsibility shortly after graduation. The geographical spread of training assignments for students of each of the colleges has followed naturally, with the result that many large companies now have cooperative trainees representing ten to fifteen different schools. And this inter-relation of students from the several colleges has been in spite of different calendars, differing length work periods, and variations in the scheduling of training assignments in the plants.

At the Mid-winter Meeting of the Cooperative Education Division in Philadelphia in January, 1954, the industrial representatives made a request for a study of the variations in the cooperative calendars of the colleges. The thought was to bring the programs of the several schools closer together, and, as explained by industry, a more closely coordinated calendar among the several colleges would result in expanded and improved training assignments for all the cooperative students. This is now impossible because of the great variation in calendars.

This study is a result of this request. A calendar of the principal cooperative colleges follows, showing the current work schedule for parallel students. Each week is represented across the page, and the time between each work period represents time in school and/or vacations. As most schools follow a pattern of pairs of students, a student in the opposite section would follow a work schedule in the intervening weeks.

Conclusions

A careful study of these calendars and the reasons behind their planning brought about these conclusions:

1. Work periods of equal length are most desirable for industrial planning, and the vacation periods are the adjusting factors in making equal work periods.
2. As a three-month period provides the maximum that a student should be away from school, it follows that work assignments of thirteen weeks should be planned.
3. "Natural" breaks in the calendar provide the best time for rotating students, and the two most "natural" breaks are Christmas and Commencement. (Easter dates are too variable to be considered.)
4. An exact quarter system rotating approximately the fourth week of September, December, March and June is the most desirable.
5. Although variations of three to four weeks appear insignificant, it should be noted that in a thirteen-week plan the maximum variation is six weeks, and differences of more than one week are undesirable.

* Presented at the Annual Meeting of ASEE and accepted by the Cooperative Engineering Education Division, Penn State University, June 20, 1955.

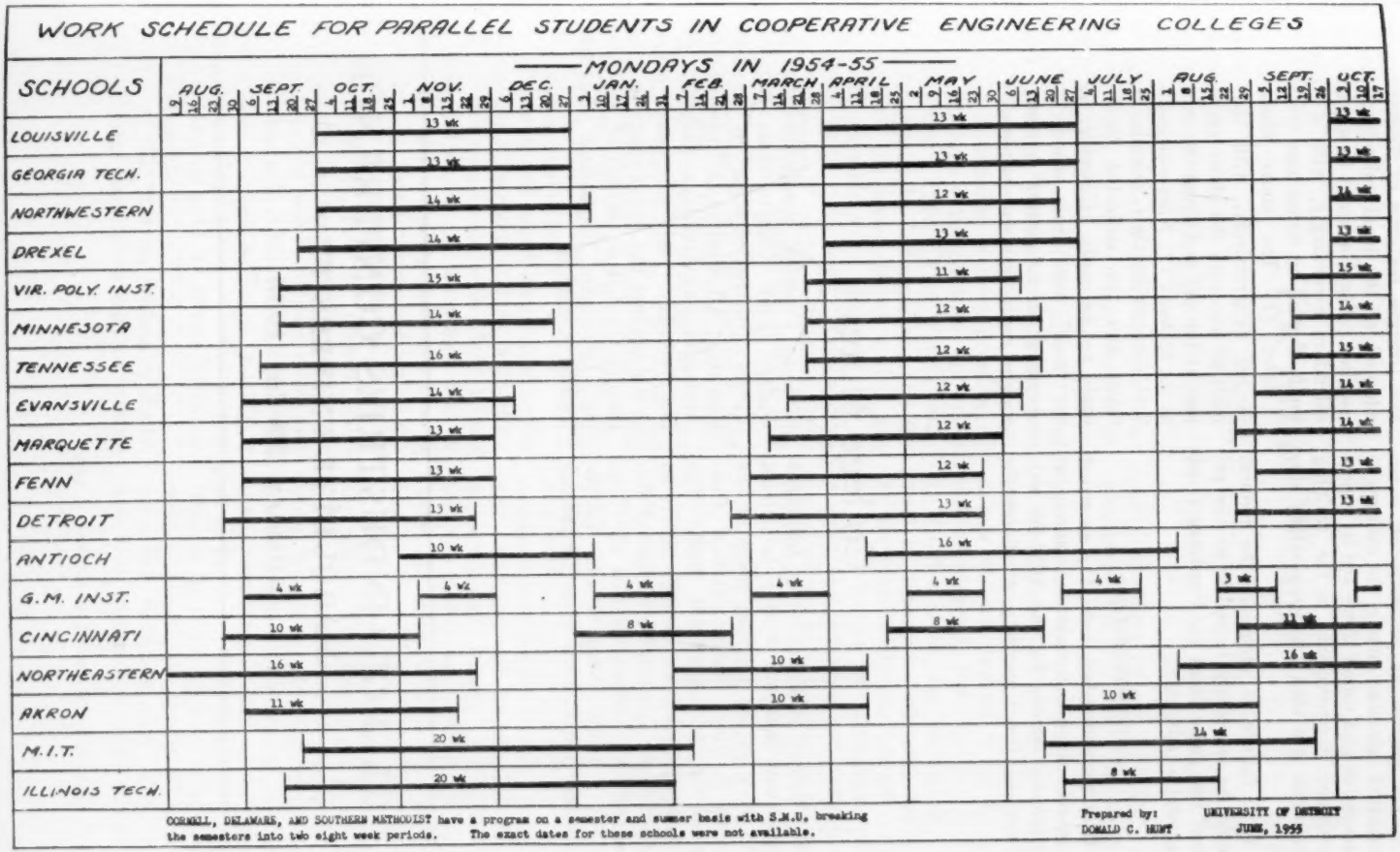
WORK SCHEDULE FOR PARALLEL STUDENTS IN COOPERATIVE ENGINEERING COLLEGES
MONDAYS IN 1954-55
SCHOOLS
AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MARCH APRIL MAY JUNE JULY AUG. SEPT. OCT.
LOUISVILLE 13 wk 13 wk 13 wk
GEORGIA TECH. 13 wk 13 wk 13 wk
NORTHWESTERN 14 wk 12 wk 14 wk
DREXEL 14 wk 13 wk 13 wk
VIR. POLY. INST. 15 wk 11 wk 15 wk
MINNESOTA 14 wk 12 wk 14 wk
TENNESSEE 16 wk 12 wk 15 wk
EVANSVILLE 14 wk 12 wk 14 wk
MARQUETTE 13 wk 12 wk 14 wk
FENN 13 wk 12 wk 13 wk
DETROIT 13 wk 13 wk 13 wk
ANTIOCH 10 wk 16 wk
G.M. INST. 4 wk 4 wk 4 wk 4 wk 4 wk 4 wk 3 wk
CINCINNATI 10 wk 8 wk 8 wk 11 wk
NORTHEASTERN 16 wk 10 wk 16 wk
AKRON 11 wk 10 wk 10 wk
M.I.T. 20 wk 14 wk
ILLINOIS TECH. 20 wk 8 wk
CORNELL, DELAWARE, AND SOUTHERN METHODIST have a program on a semester and summer basis with S.M.U. breaking the semesters into two eight week periods. The exact dates for these schools were not available.
Prepared by: DONALD C. HUNT
UNIVERSITY OF DETROIT JUNE, 1955

CHART 1

6. The request of industry for a coordinated calendar among the colleges is reasonable and sound if we are to expect continued improvements in the training programs provided for cooperative students.

7. A failure to recognize the request would be extremely impolitic as the request has come from the "customers" of cooperative education.

Recommendations

It is recommended that: (1) an exact thirteen-week quarter system rotating at Christmas, similar to the 1954–55 calendars of the University of Louisville and Georgia Institute of Technology, be adopted as the ideal calendar; (2) the member colleges attempt to arrange their calendars accordingly, with a variation limit of plus or minus one week.

Note: (1) The above chart is arranged progressively, with the schools most in line with the above recommendation at the top and those the least in line at the bottom; (2) Nine colleges indicated that changes in their calendar could be made and ten indicated that changes could not be made. However, six of the ten "no's" were from schools not now operating on a "quarter" system. There was no reply from two schools.

College Notes

The School of Engineering, **Louisiana Polytechnic Institute**, Ruston, Louisiana, will serve as the meeting place of the Fourth Annual Instrumentation Conference on November 3–4, 1955. The tentative program will include papers on the following subjects or about the following fields: Instrumentation and Control of a Large Power Plant; Instrumentation and Control of a Compressor Station; Practical Applications of Industrial Flow Colorimeters; Butterfly Valves; Instrumentation in Catalytic Cracking; All Electric vs. Pneumatic Instrumentation; Aluminum Industry; Paper Industry. All interested parties should contact the Instrumentation Conference Committee, School of Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana.

COLLEGE–INDUSTRIES CONFERENCE
MARQUETTE UNIVERSITY
January 25–26, 1956

The Art of Writing

By JOHN H. BOLTON

Editor, Iowa Engineering Experiment Station, Iowa State College

The expression of idea, whether it be in painting, music, sculpture, writing, or plan and design of a machine or a structure, is an evidence of the personality of an individual. Each individual expresses his ideas in his own peculiar way, and each is identifiable by his expression.

A Beethoven composition, an Innes painting, or a Frank Lloyd Wright building can easily be distinguished; and the works of the lesser known artists are quickly recognized by any one who is familiar with their work. Each stamps his "trademark" on his production. Because a writer shows his individuality clearly in his work, he can be identified even more easily than other artists in their productions. "I knew you had written that," one is told, "it is just like you." Teachers soon learn to distinguish the copiers and cribbers in their classes. And an editor rarely fails to discover plagiarism, simply because writing points out the writer so plainly.

We have had much instruction in the technique of writing. Many authorities have told us how to write, how to use words and sentences. They have told us how to construct paragraphs and how to outline our ideas for clear and logical expression. We have been recipients of information on how to present ideas graphically by charts and diagrams. We have been told how to prepare tables and all the other aids in expressing ideas. The time-worn expression that a picture is worth a thousand words has been drummed into our minds until we accept it without much thought.

All of that is true, without a doubt. But without another concept of writing our productions remain without a soul, uninspired, and very dull. The additional concept which requires the fullest appreciation is that writing is an art. It is not a science. There is very little beyond the basic grade school rules which can be called a science, if we limit our idea of science to the following of rules. It is unfortunate, but you will find that most of those who say that writing is an art soon fall by the wayside and try to treat writing as a science. Little wonder that students and even professional writers have difficulty in expressing themselves.

On Simplicity of Expression

Just as the greatest painting is the simplest, the best writing is simple in the way in which ideas are conveyed to the reader. All ideas cannot be simple, but most complex ideas can be expressed fairly simply. Involved phrases, clauses, and sentences add to the difficulty of understanding and are certainly not the best art. Abstruse and complicated language is not necessary for the expression of any idea, no matter how technical it may be. Every one tends to express a complicated idea in involved language; but he must, if he desires to have his ideas understood, say what he thinks as simply as he can.

Men in management positions soon learn that it is often necessary to rephrase complicated ideas and put them in simpler language if they are to be understood by their workers, whether factory laborers or technical men. The ideas in most textbooks are rephrased by teachers as they instruct a class. And, may we note here, without any intent of criticism,

that most college professors instruct classes in simpler language than that which they use when writing their textbooks. It is quite normal that they should. Oral expression of idea in instruction is naturally simpler than written expression because a speaker has his students before him and is therefore aware of them. He intentionally adapts himself to the level of understanding of his hearers. But a writer is not made to adapt himself to any level of understanding because his reader is not present when the words are set down on paper. Of course he jolly well should have his reader in mind when he writes, but quite often he does not.

A writer may argue that if he expresses himself simply he will not be credited with knowing as much as if he expresses himself in longer, more involved fashion. That may be true for those few people like himself who expect ideas to be couched in hazy, rotund verbiage. But those who are really expert in a certain field of knowledge express themselves in simple terms. It is noteworthy that usually the more a man knows, the simpler the language he uses to express his ideas. And these men are usually much more interesting than those less informed. Their complex-knowledge is through some metamorphosis expressed in easily understood terms. The reasons for this are two in number—first, the greater authority a man is, the less he needs to impress others; second, the more he knows, the better his insight and understanding.

On the Use of Rules

Every artist must have a knowledge of the rules which are fundamental in his art; but he learns quickly that rules are for guidance, not blind observance. Those best informed in any art—the critics and the teachers—are usually poor performers. Most art critics have never produced a sketch nor painted a picture. Almost every community in the nation has music teachers who, though they never perform themselves, present fair to excellent annual concerts given by their pupils.

The rules which a critic must know thoroughly, and which a teacher instills in the minds of his students, make the critic and teacher so "rule conscious" that they are usually not even third rate artists. Rules are valuable as guides, but one will never become a successful artist in any field if he slavishly follows the sign posts. This is certainly true of writing.

A reading of the publications and the usual textbooks on the subject of writing convinces one that the authorities are treating writing as a science. If every writer followed the teachings of the experts in the field, their productions would have a deadly sameness. All writings would be a stilted following of the rules and little more; for the rule makers and teachers set down exact techniques for handling every problem one faces in writing. If a writer attempts to follow those rules without thought, as many do, he fails miserably in expressing his ideas. Luckily the individual usually expresses himself rather well in spite of the experts; but too often he attempts to follow the scientific path and winds up in failure.

Of course one should follow the rules, but not blindly. For instance, every sentence must have a verb and a subject. What nonsense! Any artist in writing knows that "what nonsense" as used in the preceding is just as good as a sentence having a verb and a subject. One must consider writing as an art and strike out on his own if he desires to be successful in getting his ideas to others.

Until a writer is able to consider rules and the so-called science of writing as general, not absolute guiding principles, he cannot be a good writer. Until then he will subordinate the expression of his ideas and his personality to the following of regulations. As a result his writing may be technically correct; but it will be quite ineffective, and certainly uninteresting.

On Writing for Others

To re-state what has been implied up to this time, when one is learning the art of writing, he must also learn how to write so he can be read and understood. No artist of any consequence produces his work for himself alone. He attempts to reach the understanding and appreciation of others. The true artist knows there is no lasting satisfaction in producing for himself, but the writer who attempts to follow writing as a science never becomes an artist.

Much writing on scientific subjects is so unnecessarily involved and difficult to understand that few read it easily. This writer is certain from his survey of textbooks in science that much of the difficulty for the student-reader lies in the ineptness and the carelessness of the writer. Writings on scientific subject matter too often show the "public be damned" attitude of the writer.

Little of engineering is highly scientific, comparatively speaking. For that reason, much of the difficulty found by students of engineering is probably that freshman and sophomore texts are written by specialists who write on the college senior and post-graduate levels. Many authors do not seem to know that college students grow mentally from year to year. And none of these authors, if he were a coach of athletics, would expect every runner to break the four minute mile mark. Nor would he expect every football player to make a touchdown every time he carried the ball. But the freshman too often is expected to understand the same level of writing as the third or fourth year college student. There is little consolation for the student in this, but there is a lesson for every writer. He must have his expected reader audience in mind at all times.

On Determining Readability

Since writing is not a scientific following of rules but an art, no exact and absolute method has been or is likely to be developed for determining the ease with which a writing may be read and understood. No attempt at setting up such a standard has met with the full approval of any expert in the field of writing, so far as this writer has been able to determine.

The most widely publicized scales have in common the determination of difficulty of vocabulary plus the length of sentences. Such scales fall down because a word which may be a difficult word for one reader is not at all difficult for another. Simple one syllable words like "life" and "love" will give even a philosopher pause, and words like "trafficability" will not stop a soils engineer for a moment. A long sentence may likewise be difficult for one reader to understand but not for another. Compromises have resulted in very involved scales which have been heralded as complete answers to the problem. They are not at all answers to the involved problem of determining just how difficult a writing is for a reader to understand.

One fault with scales for finding readability is that the writer who does not know that he is dealing with an art accepts the "scientific" scale as an absolute and infallible answer. The chief fault, however, is that the originators of such scales do not accept writing as an art. If such scales were published as indications of readability and were accepted only as indications, we would have less objections to them. Writing is not an exact science but an inexact art which depends both on the personality of the writer and on the individuality of the reader for effectiveness.

A few years ago a simpler scale was developed which makes little pretense of measuring readability exactly.* The originator says that his scale indicates the difficulty of writing rather than determines it exactly. In the comparison of results obtained by this scale with the results of other scales which make claims for exact-

* Robert Gunning, "The Technique of Clear Writing," McGraw-Hill Book Co., New York, 1952.

itude, a close correlation has been found. The simpler scale is recommended to any writer who wishes to see how readable his work is. Reduced to its essentials the scale is as follows:

1. Determine the per cent of words of three or more syllables, "hard words," in the writing.
2. Determine the average number of words per sentence, counting each main clause in a compound sentence as a separate sentence.
3. Add the per cent figure and the average number together.
4. Multiply the result by .4 (four-tenths).

The result of adding apples and oranges together and multiplying by bananas is called a "Fog Index," which gives an indication of the difficulty of any writing. We do not defend this empirical method or even attempt to explain it, but we are convinced that it works. A score of nine (which corresponds to ninth grade level, if you wish to use such a comparison) indicates quite easy reading. A score of sixteen indicates college senior level, which is perhaps the absolute maximum any writing should reach. Fourteen is the more desirable limit.

Too low a readability score is an indication of galloping. For this effect read critically *Ladies Home Journal* or *Coronet,* to mention only two with scores of 7 and 9, respectively. Too high a readability score makes the assimilation of thought too much work. That is the reason why nineteenth century literature, as exemplified by the novels of Thackeray and the prose of Matthew Arnold, is no longer the popular reading of housewives and business men. Then, if you really want to work, go back to Francis Bacon and like writers in seventeenth century literature. Their writings are full of excellent thought, but much too difficult for modern taste.

A writer can easily find the readability of his work. If it is on too high a level, he can help his reader by using more short sentences and fewer lengthy words. If the readability is too low, he can combine simple sentences and make main clauses into modifying clauses or phrases. He can also choose shorter, more common words instead of longer unnecessarily technical words. Even an extremely scholarly treatise does not *have* to be difficult reading. The author has it in his power to make his writings as easy or as difficult as he desires.

Saving Time Is Important

In this day of the great flood of publications which all of us should read, the saving of time is important. A college graduate can read and understand an article more quickly if it is on the 12 to 14 level than if it is more difficult. If we have a choice, all of us select for reading the articles which are easier to comprehend. Of course special interest in a subject will lead us to choose some writing which is difficult to read, but what a relief it is to find articles which combine reader interest and moderate readability.

Consider the following selection in which only a small per cent of readers will find any natural interest. This is from the publication of a general (not specific) scientific society in England:

"Mr. T. J. Heal (Fulmer Research Institute) gave a critical evaluation of the reliability of the atomic distribution curves for liquid metals as obtained by x-ray diffraction methods. In this work the effect of incoherent scattering and scattering from atomic structure, which afford the principal contribution at large sin ϕ/A, is subtracted from the observed scattered intensity, and the residual pattern is analyzed to give the atomic distribution as a function of distance from a central atom. Errors arise from x-ray absorption, from uncertain calibration of film intensity measurements (particularly when two different radiations, usually those from copper and molybdenum targets, are used to study the same material), and from integrations over finite limits in obtaining the Fourier transform of the scattered intensity."

The average of words per sentence is 42 and "hard word" percentage is 30, which results in a Fog Index of 29, fifteen points higher than the suggested maximum for any writing, or thirteen above the absolute maximum. In justice to this publication, the sample is not typical of the whole report, which scales around 16, or two points too high. But it is no wonder that the research professor to whom this periodical goes finds little of interest and skims rapidly through the publication to find items of special interest to him.

Nor are English publications the worst offenders. Here's a selection from the output of one of the big companies in the United States:

"... The shutters also would stick or freeze shut under snow, sleet, or dirt conditions or when the shutter blades were bent enough to cause excessive friction at the fulcrum pins. The third basic fault was that, combined with the necessity for heating all of the coolant in the system, initial engine warm-up was excessive due to air leakage past the shutter blades.

"Because of the shortcomings of the thermostatically controlled shutters, research and developmental work was initiated by automotive engineers in an attempt to eliminate the shutter-type coolant temperature control and to perfect a suitable cooling system thermostat which would provide adequate coolant temperature control for car heating and satisfactory engine operation."

Whew! Yes, that is it. Three sentences, 38 words per sentence and 17% hard words. Fog Index 22, or eight points above highest advisable. No wonder one has trouble reading some external company pieces. Again this is not entirely typical, but the Fog Index on the whole article is 19, or five points above the highest desirable score.

A moderate sized company with which we are well acquainted has an external publication which regularly scores above 18. Since little of this manufacturer's product goes to college graduates, one may conclude that he is wasting both time in preparing such a piece and money in producing it. We wonder how many of the potential readers find any interest in a magazine on such a high level. Though it is presented in an interesting and attractive format, probably few copies are kept for reference by the recipients.

Professional writers could learn much from the advertising in the same publications in which their work appears. In a random check made recently the advertising in three technical periodicals had a readability of between 9 and 11, while the articles scored from 15 to 17.

The general impression from checking publications of the scientific experimental groups throughout the United States is that with few exceptions they scale only slightly above the optimum in difficulty, but about the maximum advisable, around 15 Fog Index. The research on readability indicates that when a writer is telling what he did, he uses a simple, readable style. When he explains why he did it, he gets into a more difficult, less readable style. That these publications are easier to read than the technical journals is probably because the research men usually take more time in their writing and do more revision. It also could be that most experimental organizations have fairly well qualified editors who assist in the writing.

Writing is an art, and the writer can develop proficiency just as any practitioner in any art does, by practice and more practice. Who knows but that in some future time such repetition will lead one to enjoy expressing ideas in writing. We think it worth trying. Don't follow rules blindly, but develop the art of writing and enjoy it. Keep the rules in their proper place; and do not let them interfere with the clear, easily understood expression of ideas.

Teaching Basic Electric and Magnetic Fields —A Challenge!*

By SAMUEL SEELY

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1. *Introduction*

The presentation of electric and magnetic fields to undergraduate students at the sophomore and junior level has long been a challenge to engineering educators. The difficulties in presenting this material arise from the rather tenuous character of fields, and from the mathematical demands on the student. The student has had little prior experience with fields, and to help him develop the degree of sophistication required for an understanding of field concepts in a single course often imposes considerable demands on the teacher. The student is being asked to mature rapidly in his physical understanding and perception, and also in his mathematical dexterity. This imposes considerable demands on the student.

The traditional approach to the study of fields follows from a discussion of a number of experiments which may be conducted or imagined. These are fundamentally measurements of force, and may be accomplished through the use of a torsion balance, an invention of Coulomb. Many of the fundamental experiments may, and should, be performed in the laboratory by the student. The development of the appropriate theory follows as a formulation in mathematical terms of the experimental results. This is a perfectly reasonable sequence and it is the sequence that has been developed by educators during the past half century or more. It will be shown here that an alternative sequence is possible. This alternative sequence also has its roots in experiments that the student may perform readily in the laboratory, but it is felt that this new sequence possesses certain pedagogical advantages.

2. *The Classical Approach*

The basis for the discussion of the static electric field is to be found in Coulomb's law, which expresses an experimental result in mathematical form. Implicit in Coulomb's law is the concept of "action at a distance" and the mechanism by which the force due to one charge is exerted on another charge is the electric field produced by each charge. Clearly, Coulomb's law may be considered to show that the interaction of static electric fields produces forces. Ordinarily, the preferred interpretation is that one charge in the electric field of another charge, or of a charge distribution, experiences a force on it. This leads quite naturally to the definition of the electric field intensity at a point in space as the force per unit charge at that point.

The theory develops by deducing expressions for the electric field intensity of a variety of charge distributions: point, line, surface, and volume. The results are physically general, but, mathematically, the vector integrations cannot be carried out except in a few special cases. Hence, it is necessary to continue with the development of the theory along different lines.

From considerations of the work done

* Presented at the Annual Meeting of the American Society for Engineering Education, Pennsylvania State University, June 22, 1955.

in moving a charge in the electric field, the concept of difference of potential is introduced. From this, one may introduce the absolute potential at a point, and then the notion of equipotentials, and the potential map of the field. A discussion of the potential gradient and its relation to the electric field, and the significance of the line integral follow quite logically.

While this classical development proceeds quite logically from physical experiments and reasoning, it proves to be a difficult and confusing one to the beginning student. To see more clearly why this is often so, let us review the situation. One begins with a physical law or postulate concerning the production and consequences of a field, or the interaction of fields. This is a vector relationship. The students have encountered vector quantities in their prior work in mechanics, but in a limited way. The difficulties encountered in working with vector quantities, particularly with the vector integrations involved in determining the electric field intensity of a continuous charge distribution, must be discussed. With a view toward simplifying the subsequent development, but in a manner which appears to the student as little more than some mathematical hocus-pocus, one introduces a scalar potential, the negative gradient of which is the electric field intensity. Now to add to the "clarity", the term "conservative field" is introduced, words which ordinarily, carry no connotation to the student. And then to make the situation still more lucid, the "line integral" is introduced. In this way, the entire study of electrostatics has been presented to the student. That he doesn't really understand and appreciate the subtleties of what has transpired is not at all surprising. Much of the difficulty, it is felt, stems from the fact that too little is said about the field itself, even though the student may carry out the integrations involved in the expressions that have been developed from general considerations. As a result, such problem-solving fails to clarify the fundamentals of the situation.

3. *A Suggested Approach*

A fundamental question is the following: "Is it possible to introduce the subject of electric and magnetic fields to a beginning student in such a sequence that the physical and mathematical concepts proceed from the simple to the complicated (that is, from the scalar to the vector), rather than in the reverse order?" That is, is it possible to proceed from (a) a study of the physical aspects and characteristics of a scalar field distribution, to (b) a discussion of the potential distribution in the field, then to (c) considerations of the gradient of the potential; to (d) a discussion of the work expended in moving a charge in the field, and finally to (e) the vector properties of the field itself? Fortunately, such a sequence of logical presentation is possible, and it is the experiences of Dr. Edward Erdelyi and myself at Syracuse University in presenting the study of fields in this way that I wish to discuss now. Actually, the approach to the subject is that suggested in the book, *"Einführing in die Theoretische Electrotechnik,"* by Karl Kupfmuller.

The development proceeds from considerations of the "current flow" field. This is accomplished by discussing experimentally determined flux plots, and such flux plots are obtained by the student himself in the laboratory with either commercially available flux-plotting equipment, or with locally produced equipment. This has the advantage that the student begins his study by plotting and exploring scalar fields distributions. Moreover, the concepts of equipotential lines and surfaces, and of flow lines, now become a personal experience.

The introduction of such mathematical concepts as: difference of potential, potential gradient, and line integral, proceed quite naturally in translating the observed aspects of the field into mathematical notation. The introduction of the "electric field intensity" proceeds as a definition,

as the negative of the potential gradient. The bulk properties of current and current density proceed with little difficulty, and the water flow analogy serves to provide the understanding of the current flow field. Ohm's law in field terms follows simply, but some word about its significance must be added. A general relationship for resistance follows with no difficulty. Clearly, the focus of the student is on the field, with the mathematical description following therefrom.

With the foregoing background, it is now possible to introduce the vector-analysis concept of the scalar product of two vectors, and to relate the current with the surface integral of the current density and the vector element of area (this latter must first be discussed). The first Kirchhoff law in general form is readily discussed in terms of an incompressible fluid flow, or as a conservation theorem. The second Kirchhoff law is easily related to the line integral in the field.

A variety of very interesting flow field problems are now possible for the student such as: flux plotting of a variety of field configurations, calculation of resistance from the flux plot of any specified electrode configuration; flow fields of point sources, of concentric spheres, and of spherical conductors; of line sources, grounding rods, coaxial systems, and the ground resistance of imbedded electrodes. Also, the method of electrical images is made entirely plausible from the known behavior of the current field.

4. *General Observations*

It has been our experience that work on the current flow field, with all that can be deduced therefrom, proceeds slowly. Moreover, the required mathematical manipulations still remain difficult problems for the students. However, it does seem that the students obtain a fairly good grasp of the basic field concepts, as well as the capacity for approaching intelligently problems that require an understanding of the field concept.

The subsequent work in static electric fields proceeds very rapidly, since the students are quite familiar with virtually all of the features of such electrostatic fields. Virtually the only new idea is the concept of force, that is given by Coulomb's law, and this introduces no fundamental problem in understanding. The examples of flow field problems almost make Gauss's law a trivial new concept. Similarly, their prior work on power loss provides background for understanding the idea of the energy stored in the electric field. The discussion of conductors, insulators, and capacitance, and the discussion of the mechanical forces in the electric field require some new ideas, but these seem to proceed with little difficulty.

The studies of stationary magnetic fields, magnetic effects of iron, energy and mechanical forces in the magnetic field, electromagnetic induction, and Maxwell's equations, all benefit from the student's familiarity with fields, and the mathematical representation of the field quantities. In fact, the introduction of the divergence operation and the Divergence Theorem, and the curl operation and Stoke's Theorem, at the appropriate points in the course, seem to proceed without particular incident. Nor, in fact, do Maxwell's equations in vector form seem to produce any mental block in the minds of the students.

5. *Conclusions*

In summary, therefore, it is noted that our experience with the study of electric and magnetic fields through the initial introduction and careful experimental and anlytical exploitation of the multidimensional current field shows this to be a very effective means for the presentation of field problems. The student seems better able to understand and appreciate his subsequent work than he does if the material is presented along the more traditional lines. It is noted that, while his grasp of the physical ideas is greatly improved, the mathematical complexities and difficulties remain roughly as before.

High School Science Fairs in the Fields of Mathematics and Physical Sciences*

By WATSON DAVIS

Director, Science Service, Washington, D. C.

If we are to keep civilization supplied with the technical and scientific talent necessary to a free and safe world, constantly advancing, we must discover, develop and nurture our youth showing interest and capability in science and engineering. We are engaged in a long-continued struggle between the freedom of democracy and the tyranny of autocratic communism. Democracy needs scientists and engineers to remain dominant in this struggle.

Under orders, Soviet youth are forced to become engineers and technicians in greater numbers, we are told, than our democratic educational system without duress produces technically trained personnel. Without resorting to the methods that we are confident will eventually ruin the fruitfulness of Soviet technology, America must increase the flow of its talented youth into the fields of mathematics, physical and other sciences and engineering so necessary to our future.

Experience has shown that the place to begin is as early in the high school as interest can be captured and implemented. The science club and the science fair are prime devices for doing this. Reading about science in newspapers, magazines and books, or hearing and seeing it on radio and TV is spectator science. So, unfortunately, is much too much of our science teaching. You must actually play science to understand it and appreciate it. It is, admittedly, more difficult to participate in science than to just read about it.

It is terrifically important that many of us have actual experience in science. This can best be done during the school years. For this reason in the interpretation of science, the science clubs, largely conducted as an adjunct to the secondary schools, take on such importance. In the science clubs many who otherwise would not have an experimental acquaintance with science have this satisfying opportunity. Over the years millions, who do not and should not become scientists and engineers, experience science as a hobby, to their personal benefit and to the enrichment of our national policy.

The science youth movement (for that is what it is) has the other important function of allowing the discovery of those boys and girls capable of being the scientists and technologists of the future. The young person with talent often discovers himself through the excitement and satisfaction of tackling a scientific problem experimentally.

What grass roots are to agriculture, science clubs are to science education. These bands of boys and girls are a perpetual youth movement, constantly renewed by the innate and undulled curiosity and exploratory spirit of those who are discovering, through doing, the world about them. If the future belongs to youth and to science, then there is a vastly more important place for science clubs in the scheme of things that are to be. Except that it is now given purpose, aid and encouragement through tools and programs, this ganging-up of those who want to find out

* Presented at the Annual Meeting of ASEE, ECAC General Session, Penn State University, June 23, 1955.

about nature, machines and stuff is not a very new phenomenon.

Boys have had their workshops in barn and basement. In pioneer American days the whole struggle for existence was one big experiment and the children played their early and practical part in it. Girls, too, are no new hands at this business of experimenting, except that during certain decades getting feminine hands dirty was not fashionable. But there was always the tomboy, at that.

Today it is recognized that science education must be accelerated if our growing boys and girls are to recapitulate the scientific history of the human race in the few years between entering school and getting to or through college. The formal science classes in grade, junior high and senior high schools do their part; it is a large share, too, if the pupil is fortunate enough to have a well-informed, enthusiastic and tolerantly skeptical teacher.

The informal science clubs, squeezed in after school with the help of a teacher-sponsor, or the equivalent gang that makes models, or builds a radio set, or does chemical experiments, or collects insects, getting together in the precious free time left after school or on Saturdays and Sundays —these groups have quite as much educational value and purpose as the 9 to 3 (or whatever it is) schedule. We used to hear a lot about leisure time activities, and I used to wonder how that sounded to these boys and girls who are always busy and never have time to do all they wish to do.

The "grass-roots" of science understanding is the typical club or group in a high school in some town or big city. Science is the hobby as well as the study of each boy or girl among the 20 to 30 members. A teacher who likes science, as he enjoys teaching youth, is the "sponsor." During noon hours, in class time, after school, on Saturdays, the science club members work on their projects—investigations of varying degrees of difficulty, originality and importance. The whole range of human interest and science is spanned—everything from astronomy to zoology—inventions, aids to health for the neighbors, insect collections, study of rocks, building of mechanical models, raising of animals, weather observations, food tests, chemical experiments, and thousands of other projects.

Some of these are scientists of tomorrow—and all are the citizens of tomorrow who will use and understand science. For the future of America—for peaceful living, for industrial progress, for a successful democracy, for a strong and prepared nation—this quest for science understanding must be expanded.

Great Movement

The foundations of this great movement have been built in the youth activities of Science Service's Science Clubs of America. There are more than 15,000 affiliated clubs—in every state—and almost every county, city and town of the land. A third of a million members are on the rolls of these clubs. State science academies, colleges, teachers associations, museums, newspapers, and other organizations are cooperating. In 38 of the 48 states, there is major cooperation as a part of the Science Clubs of America development.

The National Science Talent Search for the Westinghouse Science Scholarships is now in its 15th year. This is a nationwide selection of the high school seniors who are most likely to be creative scientists of the future. The selections are made through a vigorous competition based upon results of science aptitude examinations, recommendations, evaluations and science project reports. In all, 4,200 boys and girls have been picked for honors, and the National Science Talent Search has been extended into the states through the utilization by state committees of the entries for further honors.

The Science Talent Search, a Science Service activity, has pioneered the recognition by the educational and scientific world that those with talent can be picked successfully at the high school level.

The work of science clubs is culminated

in science fairs now held as part of the science club movement in about 100 localities. Science fairs attracting up to 1,800 entries, in some cases, are held annually. Newspapers and educational institutions cooperate in sending finalists from these affairs to the National Science Fair, a Science Service activity. The seventh such event will be held in Oklahoma City, in May, 1956.

Future scientists and engineers can be "spotted" about nine times out of 10 by local judges anywhere in the United States by the time the students are sophomores in high school, perhaps much earlier. But whether these boys and girls go on to realize their career potential depends in large measure on how much their community has encouraged them and will continue to guide and stimulate them.

An experiment in home town cultivation of scientists and engineers has been going on for six years through the National Science Fair, conducted annually by Science Clubs of America, administered by Science Service. In 1950, 13 communities held local science fairs and selected their best sophomores, juniors or seniors to compete in the First National Science Fair. This year 71 regions from coast to coast held affiliated science fairs. Each fair names one or two of its best as finalists to compete at the National Science Fair. This year 136 competed at the Sixth National Science Fair at Cleveland.

Stemming the scientific manpower shortage has become a cooperative grass roots operation. Educators, scientists, engineers, colleges, universities, industries, technical and civic societies, newpapers, and countless other agencies in each locality have pooled their resources and know-how to find and help the youngsters who will be tomorrow's research and technical manpower. Their skill at doing this has become so expert that it can be predicted that up to 88% of the 14- to 19-year-olds they send to the national competition will actually go on to make science or engineering their career. Many thousands of other boys and girls, too young to be sent to the national competition, or who missed it by a narrow margin, will also go into careers that will build up our pool of urgently needed scientific manpower.

Recently the 248 young people (156 men, 92 women) who were named as finalists in the first five National Science Fairs were asked to give information about themselves. Of 85% who replied, 131 were in college or other institutions of higher learning, attending 83 institutions in 28 states, 58 were still in high school, 12 were in full time employment, eight were in the armed service, and four are devoting full time to homemaking and child care. Some career choices of the 131 college students are: 41 in physical science (chemistry 27, physics 13, biochemistry 1), 31 in engineering, 28 in biological sciences and medicine, 13 in miscellaneous science, and 10 in miscellaneous non-science.

This is the picture at the culminating national science fair level. In every part of the nation a similar rise in interest in science and technology is on the march, thanks to youth, teachers and adults who realize the need of this science youth movement.

This is assurance of future national strength. The people who think, reason, discover and apply in freedom will win the future.

Aim for Ames in 1956

Risk Analysis in Engineering Economy Studies*

By F. A. GITZENDANNER

Associate Director, Engineering Research Department, Standard Oil Company (Indiana)

The object of this paper is not to describe a new concept or mathematical development. Rather its purpose is to describe some of the ways we have found it helpful in our business to use the concepts of game theory, statistical decision theory and perhaps some other names for the same general area of study. Another purpose is to suggest that such uses are properly a part of Engineering Economy and should be incorporated into the discipline.

Many engineering choices are between alternatives about which there are insufficient data and many uncertainties. Typically a low-cost alternative may be successful. However, it may fail and a higher cost step must then be used. In that case, the amount spent on both alternatives will be more than had the more expensive, and normally more certain, course been selected in the first place.

In a commercial problem, the alternatives available usually include several possible steps along quite different paths. As a result, the problem rapidly becomes very complex. Complexity alone is not insurmontable, but ways are not generally understood for handling the inherent uncertainties.

Over the past 20 years much has appeared in the literature, under various names, addressed to such problems. Our major task in trying to put it to use has been to select pertinent concepts from the technical literature and apply them to real problems. The outstanding difficulty is to devise ways of modifying the highly artificial and arbitrary conditions surrounding the game or illustration to the quite different circumstances surrounding real problems. This, incidentally, has been a far greater task than mastering the technical and mathematical concepts in the first place.

As a basic example, consider game theory which at first look appears to be the way to handle problems of low-cost versus high-cost alternatives. Game theory assumes that one's opponent is intelligent and governs his actions, in response to ours, to help his aims and hinder ours. But in engineering problems, no such condition exists. Nature is not perverse. We are merely ignorant of the true situation and therefore of the outcome of our action. This aspect, the fact that the problem of n-person games is not yet worked out and similar situations in other areas left us without a clear method for handling our problems.

A process of modification and adaption from the broad field of statistical decision work was used. This has finally resulted in what we have called a method of risk analysis. This name seemed to describe what we were doing and was free of the objections made to some other names.

Now rather than continue in generalities, I'm going to discuss specifically how we handle some typical problems.

Illustration

For purposes of illustration, I will discuss a problem which we had to decide. You are all familiar with the large storage tanks found around refineries. The particular tank in this case was 120 feet in diameter and 50 feet high and would

* Presented at the 63rd Annual Meeting of ASEE, Engineering Economy Committee, June 23, 1955, Penn State University.

hold about 3,500,000 gallons. The refinery where it was located is situated in hilly country and the storage tank areas require horizontal terraces to be excavated in the hillsides to provide the necessary level spaces. It is customary in connection with such tanks to fill them with water in order to test for leaks before putting them into petroleum service. In this particular case, approximately ¼ of the foundation area under the tank settled excessively during the initial water test. This happened despite the fact that all normal engineering studies which were made prior to the erection of the tank indicated no reason to suspect that this excessive settlement would occur. The tank was not damaged by the settlement of the foundation but was unsafe for service in that condition and the foundation had to be repaired.

Technical study of the problem narrowed the practical corrective steps down to these three. (1) Grout under the tank for $30,000, (2) excavate and put in fill, $80,000, (3) relocate the tank, $160,000. Grouting under the tank is accomplished by cutting a hole in the steel tank bottom and forcing liquid mud or cement under pressure underneath the bottom until it is raised up to the original elevation. If the surrounding soil is sufficiently strong, this is an effective repair method. In order to excavate and put in new fill, the tank would have to be moved, the weak area of soil excavated, the hole filled and fill compacted and the tank replaced.

Although relocating the tank was relatively easy, because space was available near at hand, the cost would be high primarily because of the necessity for changing piping which was already installed.

Because no one had expected the settlement to take place, sufficiently detailed measurements were not made before the water test so that definite conclusions could be reached as to exactly what happened. Soil tests and other studies made after the failure were not decisive. Among the possible causes of failure were: (1) a poorly compacted volume of soil of relatively limited extent which could be corrected by the grouting operation described above. (2) A shear failure of the soil under the tank. If soil is loaded too much it fails in shear, that is, a roughly conical-shaped plug of earth is pushed down and in turn slightly raises the level of the surrounding ground. Extremely accurate measurements are required to determine whether this has happened and unfortunately "before" measurements had not been made. It was known from the gross weight of the tank and contents that replacement soil could be provided which could stand the load. (3) The possibility that the settled portion of the foundation was actually the beginning of a small landslide. Taking even the worse of these possible explanations, i.e., the landslide, it was certain that relocating the tank at a cost of $160,000 would definitely solve the problem because test borings made after the failure showed the new site to be completely on solid rock whereas the present position was not. Although the most expensive course was certain to solve the problem, either of the two less costly methods might also be successful.

There was also the possibility that if the cheapest course were tried and failed, enough might be learned from the manner of failure to indicate a next step different from those initially considered. This second step, of course, might cost more or less than the $80,000 estimated for the excavate and fill step.

Note that the problem is completely surrounded by uncertainty and that there is a possibility of taking a "calculated risk."

Taking a "calculated risk" is a way of saying that probabilities are being analyzed and compared. Probabilities are analyzed for economic problems in the following way. Consider only for a moment the $160,000 "relocate" and the $80,000 "excavate and fill" alternatives. A definitely satisfactory result could be obtained at a cost of $160,000. If the $80,000 excavate and fill alternative were tried first and failed, the satisfactory correction would then cost that $80,000 plus $160,000

more to relocate the tank or a total of $240,000. Therefore, if the $80,000 first step alone were successful one-half the time, the average cost of all cases would be the same as using the $160,000 alternative. Stated differently, a 50–50 chance (50% probability) of success for the "excavate and fill" course is the break-even point. If the chances of the "excavate and fill" step succeeding were better than even, then that solution had the greatest probability of being the most economical selection. It must be remembered, however, that the theory of probability predicts what will happen in the "average" case and not in a single case.

At this point, the next step might appear to be that of estimating the respective probabilities of the different courses being successful and proceeding directly to selecting the most economical choice. You will find that most real problems are so complex that this does not work out for two reasons: first, even given the probabilities, it is impossible to visualize the interactions of the various factors without benefit of pencil and paper and algebra. Second, the probabilities associated with respective alternatives cannot be objectively established very well and the people making the decision must also weigh the probabilities which have been assumed when they are making the decision. Having these principles in mind, we can proceed with the analysis.

Analysis

The first step in the analysis is to list all possible courses of action. Each course must include not only an initial alternative which might succeed, but can proceed through various subsequent steps and end with an alternative which is virtually certain to succeed. In this problem, the only alternative certain of success was to relocate the tank. (If one of the intermediate steps has some likelihood of damaging the tank, this is reflected in a greater than $160,000 cost for the final relocating step.)

Following out the rule just stated and applying what has been stated about the

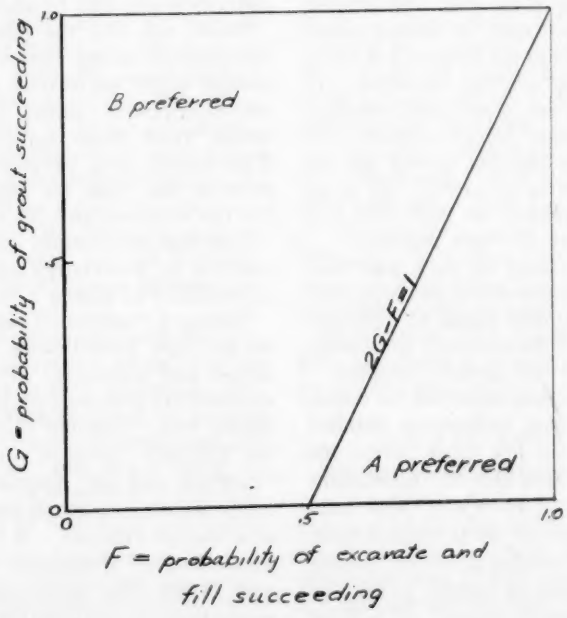

FIG. 1

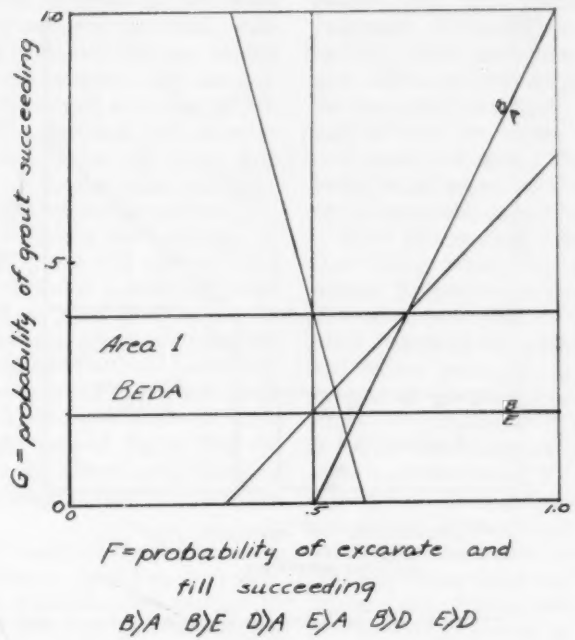

FIG. 2

problem of the storage tank foundation, it can be developed that there are a total of five alternate cases having 23 possible courses of action.

One case, for example, assumes (1) that no damage to the tank will be caused by the failure of any of the repairs, (2) that earlier steps do not influence the cost of subsequent steps and (3) that no useful information will be gained from watching the manner of failure of one of the earlier steps, should it fail. For this case, the possible courses of action are (A) grout and move, (B) grout, excavate and move, (C) excavate, grout and move, (D) excavate and move, (E) move. Note that in each case, any one of the alternatives could prove successful and, of course, work would be stopped as soon as a successful solution is found.

Equations for probable costs of the different possible course of action in terms of the respective probabilities of success for the individual steps are then set up. Specifically, if G equals the probability of the grout step being successful and F the probability of the excavate and fill being successful, the equation making the probable cost of course of action A equal to that of B is $30G + 190(1 - G) = 30G + 110(F - G) + 270(1 - F)$. This equation reduces to $2G - F = 1$ and the graph of this equation is shown on Figure 1.

Combinations of probabilities lying on the line are on the break-even point. Combinations of probabilities giving points to the upper left section indicate the B course of action to be preferred, and in the lower right, the A to be preferred.

Probable costs of all courses of action are similarly equated and the solutions are shown in Figure 2.

Consider Area 1 for a moment. In Area 1, B is preferred with respect to A, and also B is preferred with respect to E. A similar study of the diagram with respect to each line on it gives preferences in the order shown below the chart for

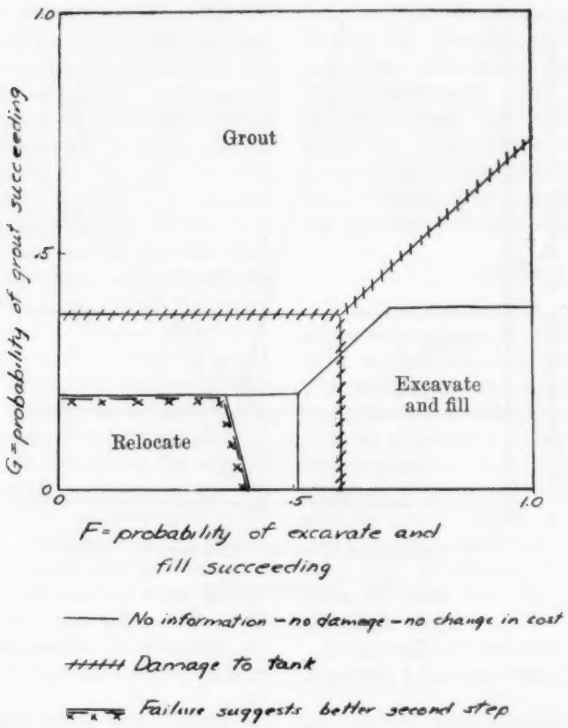

FIG. 3

Area 1. This preference order can be listed as shown in Area 1 on Figure 2. By similar reasoning the chart can be divided into three areas. These areas indicate courses having the odds in their favor for all possible combinations of probability of success for the alternatives.

Other cases to be considered include (1) when the failure of any course leads to high subsequent cost because of damage or (2) when failure of one of the courses leads to indications that cheaper, or more costly, alternatives should be taken rather than those originally contemplated.

The analysis of the five cases and twenty-three sub-cases is summarized in Figure 3.

On this composite chart, for example, the case which assumes the initial failure damages the tank and thereby makes subsequent steps more costly, requires a higher likelihood of success for the grout method than do the other assumptions. This is what would be expected. Similarly, the assumption that observing the method of failure of the grout case will suggest a second step less costly than the $80,000 excavate and fill step counsels for only two choices, i.e., grout or relocate. This is to be expected on the basis that if the $30,000 course is tried and fails, but the observation of the failure suggests a $20,000 second step, both of these steps could be obtained for $50,000 which would certainly be preferable to spending $80,000 initially.

Figure 3 summarizes the economic situation. When one locates his position on this graph, the preferred course of action is clear.

Unfortunately, dependable estimates of these probabilities were not available. It

is often erroneously assumed that when technical questions are involved, estimates of such probabilities are readily available. On the contrary, they are generally not available and were not in this case either. The problem was to make the best estimate taking all things into consideration. A chart similar to Figure 3 was used in this estimating process.

The line of reasoning was somewhat as follows: (1) If grout will succeed, it is probably true that only a relatively small volume of soil is weak and it can be strengthened by the grouting procedure and the load will be effectively carried by the surrounding soil. If this is true, then excavate and fill will succeed as well. This suggests that the area of Figure 3 to the lower right of a 45° diagonal line passing through the origin contains all reasonable situations.

For a 50–50 chance of grout being successful, the choice is clear for every case except the one which assumes damage to the tank. Technical considerations of the possible manner of failure of grout, however, strongly indicate that damage to the tank is not likely to occur.

Note also that if no damage occurs, for a 50–50 chance for grout, the decision does not depend on whether the proper value is 45–55 or 55–45—the split need only be better than 1 in 5 in the left portion of the chart. High probabilities of success for excavate and fill technically implies good probability for grout succeeding since high probability for excavate and fill would be the consequence of a strong surrounding soil which is not likely to fail, i.e., it is probably not the beginning of a small landslide. This situation would naturally be favorable for a grouting operation.

If faith in excavate and fill is rather low, it must be on the technical basis that extensive soil volume is of questionable strength. In this event, the chances in favor of grout must be reduced accordingly. This throws the case into the area favoring relocating the tank.

As can be seen, the use of this type of analysis does not eliminate the need for judgment. Reasoning such as above helps to clarify one's understanding of the technical situation and specifically indicates the economic inter-relationships. It does not indicate the values of probabilities that should be used. The best available technical judgment on these points is still an indispensable ingredient.

What this method does is to calculate those things which can be calculated and directs judgment at the critical point. For example, in this case, the initial technical judgment by competent engineers, and before seeing this kind of analysis, considered the probabilities in favor of grout being successful to range from 50% to 90%, i.e., some engineers stated 50, some engineers stated 90. This seems like a large area of disagreement and the various values were strongly supported by thoroughly competent technical experts. The interesting thing was that even granting any one of these values to be correct, the preferred course of action was by no means clear.

When, as a result of this type of analysis, the economic inter-relationships were developed and it was seen that the critical point for grout being successful was of the order of 20%, the problem assumed a different complexion. Whereas the engineers were not sure exactly what grout's probability was, they were very confident and in agreement that it was definitely better than 20% and very likely higher than 50%. On this basis, the preferred course was quite clear and used. Incidentally, it proved to be successful.

Other Problems

The same general kind of analysis has been applied to other problems. For example, in another instance we were faced with the problem of selecting between two designs of equipment. In a large plant, a change in process required the modification of two existing plant units. The original plant consisted essentially of two half-plants in which the units in question performed identical functions.

In the modified plant, the two units would also carry out substantially the same step. The problem concerned whether the same design should be used in both units or whether a different design should be put in each.

The costs of the two types of units were practically identical and were less than the fixed cost of one month of plant operation. The time required to obtain one of the units was about eight months. The two available designs were quite certain of working satisfactorily to some yield level. It was not known precisely what yield level could be expected from each, particularly which of the two was better, and a difference in yield of 5% was financially sufficient to warrant replacing the poorer one.

The problem was—what to do.

The initial risk analysis along the lines described in this paper finally boiled the problem down to understandable proportions. If the same design were installed in both units, it was equivalent to a bet of 3 to 2 that we were able to select the better design; the use of different designs in both was taking the opposite side of the bet, i.e., betting 3 to 2 that we could not select the better design.

In the light of all pertinent factors, it was decided that the better design could be selected. Orders were accordingly placed for two identical units and the matter considered closed.

Concurrently, laboratory and pilot plant work was proceeding and recently information was developed indicating that a design other than the one selected would prove to be better. Engineering studies developed that the design initially selected could be readily modified to the type indicated by the laboratory work. The fabrication schedule was such that one or both of the units ordered previously could be modified with slight delay to the project.

At this point, it should be stressed that both the lab data leading to the original selection and the new data leading to the different conclusion were not as clear cut as this paper may suggest. Time did not permit the exploration of all the quite obvious technical questions. Nevertheless, new data were available leading to different conclusions and time was available to make a change. The question again was—what should be done.

The data suggested that two of the modified design units should be installed. There was no certainty, however, that the latest data would not in turn be revised in the future. At the same time some factors also still indicated the original design to be good.

Again risk analysis, which took into account the new economic situation existing by virtue of commitments on the initial two units, as well as all other items involved in the plant, reduced the problem to understandable terms. To install two modified units would take considerable risk that the latest data were not correct. Specifically chances of 1 or more in 3 that the latest laboratory data indicated the incorrect *direction* of superiority counsel for installing one of each rather than two of the modified design. Note that this is different from the usual requirement that lab data show the relative merit quantitatively. The relationship of pertinent costs in this case was such that the key question was:—which is better. How much better was immaterial to the decision.

This problem, it might be mentioned, is current—so much so that the decision has not yet been made. Of interest here, however, is the fact that the initial discussions about the problem were along the conventional confusing lines characterized by vague discussions of uncertainty. The application of the risk analysis technique introduced a quantitative way of considering uncertainty in terms which were considerably more familiar to all concerned. Whatever the ultimate decision, it will have been made in a clearer understanding of the risks and their effects.

Summary

In summary, we believe that this is a useful technique for considering uncertainty in typical engineering economy problems. We have used it in connection with six widely different problems. In each it has been of use in translating the uncertainty in the situation into understandable terms frequently with some comparison to familiar experience. Risk analysis requires engineering competence, understanding of sound economic principles and ability to synthesize these elements into a composite story suitable to the problem at hand. We believe this type of analysis will prove of increasing value in industrial applications and has a place in the teaching of enginering economy.

ANNUAL MEETING

June 25-29, 1956

Iowa State College

Ames, Iowa

Report of the Secretary 1954—55

This report covers a period during which two secretaries functioned and has been prepared independently by the new secretary. It is thus possible that some items of significance may have been overlooked or inadequately treated. For such omissions apologies are extended.

Change in Secretary

The most significant event of the year was the resignation of Secretary A. B. Bronwell to accept the presidency of Worcester Polytechnic Institute. After the naming of the new Secretary the national office was moved to the University of Illinois, Urbana, Illinois. The office is conveniently located on the first floor of a former residence owned by the University and immediately adjacent to the campus.

The University is providing the space rent free, furnished funds for adapting the residence to office use, and provides the long-term maintenance necessary to keep the building in good condition. In addition, because the editorial secretary needs to divide time between the ASEE Office and the editor's office, the University is furnishing the needed space and equipment in the editor's office.

The Society is responsible for the cost of utilities and day to day janitorial services. By action of the Executive Board the Society purchased sufficient furniture to equip all the offices. Since the Society already owned all the mechanical equipment, the Society now is essentially independent of the host institution in so far as furniture and equipment are concerned.

The editing of the JOURNAL OF ENGINEERING EDUCATION was to be transferred from Professor C. E. Watson of Northwestern University to Professor L. A. Rose of the University of Illinois, on July 1, 1955. The sudden and untimely death of Professor Rose delays the date of such a change and Professor Watson has agreed to function as Editor until other arrangements materialize.

Unfortunately, no one in the Evanston office was able to move to Urbana. Consequently the office staff is entirely new and consists of

Executive Office Secretary
Mrs. Naomi Garman
Membership Secretary
Mrs. Louise Chambliss
Editorial Secretary
Mrs. Sandra Sokolow
Typist
Mrs. Elsie O'Brien

Each of the new staff, except the typist, was able to spend from two days to almost two weeks in Evanston in order to be briefed in their respective duties.

In establishing the office in Urbana the first objective was to systematize the routine matters of operation; secondly came the Annual Meeting. Almost all other matters were placed on a lower level of importance and thus relations with the General Council, Division Officers, and Committee Chairmen most probably have not been as close as they should have been. Some desirable activities and procedures were not carried out, such as the President's Newsletter, providing information to members of the General Council in advance of the meeting, and providing a semblance of helpfulness and willingness for cooperation to committee and division officers.

Projects

1. *Evaluation of Engineering Education.* The Interim Report presented last year has been revised to reflect the comments of the institutional committees which studied it in detail. The final report of the committee will be presented at this year's Annual Meeting and copies will be available to those attending the meeting. The completion of this project was made possible by additional grants of considerable magnitude by the General Electric Company and the United Engineering Trustees, Inc. The society greatly appreciates their continued support.

2. *Humanistic-Social Research Project.* A preliminary report is to be presented at the Annual Meeting and the final report will be completed and published in the Fall. This report on what actually is being done at some institutions should be a valuable supplement to the report on Evaluation of Engineering Education.

3. *Educational Aids.* The booklet has been printed and is available from the Secretary's Office for $1.00 per copy. About 500 of the 2000 copies printed have been sold.

4. *ASEE–NSF Conferences.* As a result of the two successful Summer Institutes of last year, three ASEE–NSF jointly sponsored conferences were held. Each of these two-day closed conferences of about twenty-five leaders in various fields of engineering, as well as from mathematics and physics, was financed by the National Science Foundation. The program and personnel invited also were developed with their close cooperation. The report on each of these conferences is in the May issue of the Journal of Engineering Education. The findings of each of these conferences are the bases for open discussion meetings at the Annual Meeting, or, in the case of thermodynamics, the conference following the Annual Meeting. The conferences were all held in February and are as follows:

Mechanics—Physics
New York University
Electricity and Magnetism
Lehigh University
Thermodynamics
Purdue University

The Society is deeply indebted to the National Science Foundation for its great interest and cooperation in organizing and sponsoring these conferences as well as for its financial support.

5. *Graduate Study Project.* The ad hoc committee on the preparation of the Graduate Study Project has proceeded with its plans for an extensive study of graduate work. The program submitted centers on "Current Problems of Graduate Education in Engineering." Five problems have been agreed upon and briefly may be stated as being:

(1) Since high level industrial employment profoundly affects the caliber of students entering graduate schools, is a cooperative program between universities and industries indicated to assure the nation an adequate supply of graduate engineers?
(2) The effect of sponsored research and research fellowships on the development of student initiative and leadership.
(3) Part-time programs at the graduate level, flexibility and standards.
(4) When and under what conditions can an institution effectively undertake graduate work?
(5) The scope and breadth of graduate work, particularly for men already employed in industry.

A budget is now being submitted to the Executive Board along with proposals for financing.

6. *Theoretical Engineering.* The ad hoc planning committee under the chairmanship of Dean F. C. Lindvall has proceeded in accordance with its instructions of last year. A conference with representatives of the National Science Founda-

tion will be held at the Annual Meeting. It is contemplated that the closed conference be at the California Institute of Technology and the open conference at the University of Michigan.

7. *Summer Schools.* The Society is sponsoring two Summer Schools and one Conference this year. All are being held at The Pennsylvania State University and are as follows:

English Division—"Communication: experiment and experience"

Chemical Engineering Division—"What's ahead in chemical engineering education?"

Thermodynamics Conference—"Developments in thermodynamics having an impact on engineering, technology, science and teaching."

The Society cooperated with these projects by publishing a brochure and mailing it to some five hundred deans, directors, etc. and in other miscellaneous ways.

8. *YET Activities.* Interest in the YET program has continued, even though no specific charge such as conducting a membership campaign was assigned them. Thirteen of the sixteen sections submitted papers in the contest. This year, the winning papers will be read at the Annual Meeting and all thirteen papers are being submitted for possible publication in the JOURNAL OF ENGINEERING EDUCATION.

Membership

The individual membership in the Society has continued to increase. The number listed in the 1955 Yearbook is 7560 whereas it was 7095 in 1954 and 6875 in 1953. At this year's Annual Meeting, 15 members are being recommended for life membership; 250 have resigned, 42 have died, 99 are more than two years delinquent in dues, and 917 have not paid their dues for the year despite receiving three dues notices. The last figure seems to be much greater than in past years and must be reflected in next year's budget.

After the concentrated effort of the past two years it was thought desirable not to push Institutional membership; instead it seemed advisable to observe the stability of the recent growth. The 1955 *Yearbook* lists 112 such members, whereas 96 were listed in 1954 and 35 in 1953. During the year two dropped their membership and ten have not paid this year's dues. The active support of this type of membership is desirable and the committee will renew its promotional activities next year.

The number of Active and Affiliate Institutional Memberships also has increased slightly. The yearbook figures for the former are 29 for 1955, 28 for 1954, and 27 for 1953. The Affiliate totals are 29 for 1955, 28 for 1954, and 27 for 1953.

Relation with Industry Division Meetings

The Relation with Industry Division and the Iowa Engineering Society held a "College Industry Conference" at Des Moines, Iowa in March. About four hundred attended the various sessions devoted to a discussion of current problems facing the engineering profession, especially as they affect the young engineer and his development and progress in industry.

This important division, linking ASEE closely to industry, has as the theme for its Annual Meeting program "How Do We Compare Scientifically with the People Behind the Iron Curtain?" The presentation will cover the legislative matters affecting the training and utilization of scientific and engineering manpower in this country and in Russia, and the quality and quantity of the scientific and engineering education in the two countries.

Division Publications

Last year's report of the Secretary listed the publications of the Divisions, recognized their value, and gave credit to their editors. The publication of such periodicals is becoming increasingly difficult, at least in two instances, because of the withdrawal of the support which enables them to be provided to all members of the Division at no cost. Present publications and the editors are:

Civil Engineering Bulletin
A. A. Brielmaier, Washington University
Chemical Engineering Transactions
A. H. Cooper, University of Maryland
Heat Power News and Views
J. S. Doolittle, North Carolina State College
Journal of Engineering Drawing
W. J. Luzadder, Purdue University
Machine Design and Manufacturing Process Bulletin
E. E. Day, University of Washington
Mechanics Bulletin
A. W. Davis, Iowa State College

Cooperation with Other Organizations

During the year the ASEE continued its active participation in the affairs of the Engineers' Joint Council, Engineers' Council for Professional Development, etc. Dean Thorndike Saville again served as President of EJC. The Society is cooperating with Lehigh University, the American Institute of Steel Construction, and the American Society of Civil Engineers in sponsoring a summer course, "Plastic Design in Structural Steel," to be held at Lehigh University, September 7–15, 1955. The Society provides no financial support.

By virtue of its membership in Engineers Joint Council the Society is instrumental in EJC's planning of the Nuclear Engineering and Science Congress to be held at Cleveland, Ohio, December 11–17, 1955. Twenty-four organizations with a total membership of 250,000 will participate and almost 200 papers have been submitted for presentation. The purpose of the Congress is to discuss the pressing problems of nuclear engineering and the related sciences, with emphasis on the industrial usefulness of atomic power.

ECAC and ECRC

The activities of these organizations are reported separately in this issue of the Journal.

It is only appropriate to acknowledge, in closing, the whole-hearted and unselfish cooperation given the new Secretary and the new office staff by former Secretary A. B. Bronwell, former Executive Office Secretary Miss Marion Strohm, and Assistant Secretary C. E. Watson. We are all grateful for their aid in helping us overcome some trying situations. The patience and courtesy of President N. W. Dougherty is also greatly appreciated.

Respectfully submitted,
W. LEIGHTON COLLINS, *Secretary*

Report of the Vice President, Leo J. Lassalle, in Charge of Instructional Committees and Divisions For the Year 1954–55

On June 15, 1954, at the Annual Meeting of the ASEE in Urbana, Illinois, I was elected Vice President of the ASEE in charge of committees to succeed Vice President W. C. White. Vice President White was very helpful to me in outlining the duties and responsibilities of my new position, and I wish to thank him for this valuable and willing assistance.

On July 12, 1954, the new President of the ASEE, Dean N. W. Dougherty, of the University of Tennessee, called the then Secretary, Prof. A. B. Bronwell of Northwestern University, and me to a meeting at his office in Knoxville, Tennessee, for the purpose mainly of considering the selection of chairmen and members of the various committees of the ASEE.

We met all day and agreed upon the main appointments. Necessarily, certain details had to be left to the Secretary and President for further correspondence, discussion and decision. However, as the result of the meeting, the present commitees were named and have been functioning efficiently, as indicated by the work they have done in planning the Annual Meeting at The Pennsylvania State University.

The Executive Board of the ASEE met in New York City and transacted the business of the agenda. See agenda and minutes of this meeting for details of this meeting which was held September 11, 1954.

On October 27–29, 1954, The Executive Board as well as the ASEE Committee on the Annual Meeting met in Cincinnati. These meetings coincided with the ECPD at the same time and place. The business transacted is detailed by the agenda and the minutes of the meeting at the Hotel Alms, Cincinnati, on October 27–29.

Prior to the above meeting, and after it, the Executive Board was confronted with the impending resignation of the very able, experienced and efficient Secretary of the ASEE. The fact that he was resigning to accept the presidency of the Worcester Polytechnic Institute made us proud of him, but it did not lessen the gravity of the problem of selecting his successor and the dislocation caused by the change.

President Dougherty took all necessary steps, with the aid of the Executive Board, to set in motion the necessary machinery for the selection of a new Secretary. Among other actions, he addressed a letter to the deans of the various engineering schools that are institutional members of the ASEE and to others, asking for their suggestions and assistance in the selection of a new Secretary. By this method, and after additional meetings of the Executive Board and committee appointed by them, we were very fortunate in securing the services of Prof. W. Leighton Collins, of the College of Engineering, University of Illinois, as Secretary.

Our thanks are certainly due to Dean W. L. Everitt for his assistance in working out the many details of this appointment, as well as to Professor Collins for accepting this difficult assignment.

On November 16–18, 1954, the Executive Board met in Washington, D. C. on the occasion of the Annual Meeting of the Association of Land Grant Colleges and Universities there.

We again considered many matters as indicated by the agenda and the minutes

of this meeting. This was the last time we were to meet with our past Secretary, Prof. A. B. Bronwell, in charge of details and arrangements. He assumed the presideney of Worcester Polytechnic Institute on Feburary 1, 1955 and Professor Collins assumed the secretaryship then.

On March 26, 1955, I attended the Annual Meeting of the Missouri-Arkansas Section of the ASEE as representative of the Executive Board and I was the main speaker at their banquet. I brought the greetings of the Executive Board and spoke on "The American Society for Engineering Education and its Work in the Years Ahead."

On April 15, 1955, the Executive Board met in Knoxville, Tennessee in President Dougherty's office on the occasion of the Annual Meeting of the Southeastern Section of the ASEE at the University of Tennessee. This was our first Executive Board meeting with Professor Collins as Secretary of the ASEE; and he demonstrated that he had been well-tutored by the outgoing secretary and that he was an apt pupil, by presenting the Executive Board with the usual well-prepared agenda and by assisting us in transacting the business presented to us.

At this meeting, among many other actions as shown by the agenda and the minutes of the meeting, we elected Prof. Lisle A. Rose as Editor of the Journal of Engineering Education and Public Relations Director of the ASEE to succeed Prof. C. E. Watson, who necessarily had to resign this position, due to the fact that the Editor and Secretary cannot function properly in their related duties unless their offices are located close to each other.

Prof. Lisle A. Rose was to assume office on July 1, 1955. We, as well as his many other friends, were shocked and grieved by the sad news of his sudden death before he was able to assume his new position. The ASEE has suffered a great loss as Professor Rose was an able and indefatigable worker, who possessed the rare combination of ability and enthusiasm that would have made him a great editor of the JOURNAL OF ENGINEERING EDUCATION, but for his sudden death. I can only join, in an inadequate manner, in expressing to his family and friends my sincere sympathy.

The work of the many committees and of the outgoing and incoming secretaries and their staffs can best be shown by the reports of the activities and by the meetings planned and held here at The Pennsylvania State University in connection with the 63rd Annual Meeting of the American Society for Engineering Education.

Annual Report of Vice President, B. R. Teare Jr., in Charge of Sections and Branches June 17, 1955

The Sections and Branches of the American Society for Engineering Education have had another healthy, vigorous year. Their programs have been stimulating and well attended as I know from first-hand observation at the meetings in which I have participated.

As I reported last year, I have been giving much thought as to how the various subdivisions, Sections, Branches, Divisions, Committees, and so forth, of the Society best can be integrated with each other, and how the totality of subdivisions best can serve the individual membership of the Society. We may think here of two kinds of service: one, originating, developing, and formulating ideas that will advance engineering education; and

the other, communicating them with penetrating discussion and criticism throughout the Society. The development of ideas can and should occur in every subdivision of the Society; indeed, Divisions and Committees are organized expressly for this purpose, and the various topics of interest to the Society are apportioned among them. On the other hand, Sections and Branches are free to consider ideas of any kind, ideas that may also lie within the province of any one or of several of the Divisions and Committees.

Sections play a very important role in the Society structure by providing excellent opportunities for the communication and discussion of ideas, supplementing the national meeting. This needs reinforcement because it is limited in duration and because sessions compete with one another. A Division or Committee program often cannot reach all members of the Society that are interested; some are not able to come to the annual meeting, and those who do cannot be in two sessions at once. Sections, however, provide excellent alternative channels of communication. Their programs can be organized around fewer topics which lessens conflicts. Also, in most instances, the Section is small enough so that travel to its meetings is not as difficult as to the national meeting, and yet the Section contains enough different institutions, 5 to 22, to provide a stimulating diversity of point of view.

Thus, if the communication of ideas within the Society is to be improved, and many members feel that this would be desirable, one method of doing so is by working through the Sections. It may be that ways can be found to increase the already good attendance at Section meetings, and reach more members who do not attend the national convention. Also, I think that the Section programs to a greater extent than now can be directed toward the dissemination and discussion of matters that are of current interest to the Society as a whole. In my contacts with Sections I have been urging an increased cooperation between Sections and Divisions to this end. More often than is done now a Section might choose one or two Divisions to help plan and put on its meeting. The Divisions called upon would probably be one like Educational Methods, Graduate Study, Relations with Industry, or others; that is, of the kind that are the concern of more than one major branch of engineering. Alternatively, a Section might call upon a Committee that is working on a major Society project. The Division or Committee would assist the Section in planning the program, but the actual participants might well be members of both groups.

Such cooperation is to the advantage of both the Section and the Division. The Section gets help with its programs, and these are kept within the main channels of Society thinking. The Division has the opportunity of reaching more members, and this means more discussion and criticism to aid in the development of ideas.

A few Sections are so large, with distances between institutions so great, that attendance at meetings seems quite expensive. It has been suggested that consideration should be given to boundary changes that would reduce distances to be traveled. However, in several discussions I have held with the officers of large Sections it has seemed clear that in spite of present disadvantages there is little sentiment in favor of a change. To force a change is unthinkable; our tradition is to give the Sections fullest autonomy in all their affairs.

In the last few years many industrial organizations have joined the Society as associate members, in part as the result of a successful membership campaign. Such members may be distinct assets to Sections and Branches, but only if they are included in Section and Branch activities. This would be desirable from both the local and the national points of view.

During the year, in the course of revising the constitution of the Upper New York Section, it was pointed out that Article IX, Section 3, of the National Constitution may need revision. Here the Constitution states that

"Section 3. Papers and discussions presented before Sections or Branches shall be the property of the Society and may be published as Society proceedings if authorized by the Publication Committee. Permission to publish such papers and discussions elsewhere may be granted by the Executive Board of the General Council on condition that the Society receives proper credit."

This mandate may not be completely enforceable because in some cases a Section or Branch may invite a distinguished man to appear on a program and may not feel that it is in a position to claim his paper as Section or Branch property. The matter has been referred through the Executive Board to the Committee on Constitution and By-Laws.

It has been a great pleasure to be associated with the able officers and members of Sections, and I gratefully acknowledge their help in carrying out my duties, also the splendid cooperation of our national headquarters.

Annual Report of the Chairman, Harold K. Work, of the Engineering College Research Council June, 1955

During the past year, the Engineering College Research Council has continued to work on the various problems facing engineering schools, doing sponsored research. The basic problem has been approached in various ways, which are detailed as follows:

Publications

A new edition of "Review of Current Research and Directory of Member Institutions" has been prepared and will be available early in July. This booklet should be valuable to all of our member institutions, to individual faculty members, and to sponsors who are trying to locate and evaluate institutions for handling their research. The Secretary of the ECRC, Mr. Renato Contini, has been responsible for this publication.

A committee under Eric A. Walker has been working on the preparation of a book on "Creativity in Research." They are using as source material a group of papers presented at various symposia and meetings sponsored by the ECRC. In addition, some special solicited papers may be included. The available material is now being evaluated by a publishing house.

The Committee on Relations with Federal Government Agencies under R. J. Woodrow has prepared a brochure entitled "Sponsored Research Administration." This is an excellent handbook, covering many problems of interest to the research administrator. It will be published and distributed to member institutions. Provision may also be made to make it available to others.

Relations with Federal Government Agencies

The Committee on Relations with Federal Government Agencies under R. J. Woodrow has continued to be one of our most important and active committees. The Committee has considered a variety of subjects and a brief resumé of such activities will be given here.

Overhead and direct cost of research conducted for the Government are being

studied by the committee. A problem exists with the Department of Health, Education and Welfare and others, who do not want to cover the full cost of the research. The Committee will continue to press for a single standard of payment for research in which research costs are fully reimbursed above the lines of the Mills formula.

A regulation promulgated and distributed by the Department of Commerce which imposed severe limitations on engineering schools in the performance of their functions in education and research was the subject of considerable concern. Through the activities of the committee the regulations were redefined in such a way that it minimized the objectionable features as far as educational institutions were concerned.

Relations with Industrial Research Agencies

The Committee on Relations with Industrial Research Agencies under S. T. Carpenter continued to maintain relationships with those organizations most concerned with industrial research. These included the Research Committee of National Association of Manufacturers and the Industrial Research Institute. An attempt was made to arrange a regional conference with NAM but this did not materialize.

As a part of the annual program the committee arranged joint sessions with the Graduate Studies Division on subjects of interest to industrial research people as well as engineering research people.

Awards

At each ASEE Annual Meeting a series of awards is given for various educational activities but there is no award specifically aimed at the stimulation and improvement of engineering research. A Committee was set up under the chairmanship of R. J. Martin to determine whether or not such an award was desirable. This was decided in the affirmative and the committee is now trying to define the nature of the award and arrange for its financing. It is the intention to announce at the 1955 annual meeting that such an award will be initiated in 1956.

Basic Research

The Committee on Basic Research, which was originally set up to help the National Science Foundation in its engineering research activities, has been dropped as its services are no longer needed.

Research Administration

Many of the problems in the administration of sponsored research are not covered by our present committees. For example, the excellent salary analysis recently prepared by Virgil E. Neilly would fall in this category. It was decided, therefore, that a committee was needed on research administration which might study various problems in research, such as (1) overhead costs, (2) security requirements and (3) extra salary payments for staff members engaged in classified research, etc. R. A. Morgen was appointed chairman of the Committee and selected as his first project, the study of how research personnel, in various research organizations, are handled in the matter of tenure, fringe benefits and so forth. The Committee is also considering a study of standardization of reports.

Program for the National Meeting

The program committee under the chairmanship of R. G. Folsom has developed an interesting program. In order to be certain that people interested in both education and research would find something of interest in the program, the general session involves relationships between the two. Three eminent speakers, two of which are engineering school presidents and the third a corporation president, have been secured.

Another joint dinner has been arranged with the ECAC and Dr. E. W. Engstrom,

Vice President of the Radio Corporation of America, will be the speaker.

Two joint, open sessions have been arranged with the Graduate Studies Division. It is felt that the combination of our activities with those of other committees should be encouraged in the interest of converting small competing meetings into better joint meetings.

As is customary, a closed session will be held at which the various problems of ECRC members will be discussed on a more or less confidential basis.

Four executive committee meetings were held during the course of the year as well as numerous committee meetings.

Nominations

The Nominating Committee under the Chairmanship of Frank W. Dawson presented names to replace the following officers who are retiring:

R. A. Morgen
F. C. Lindvall
G. R. Town

Those nominated by the committee and elected by the ECRC representatives are as follows:

K. F. Wendt
T. J. Killian
H. W. Barlow

Annual Report of the Chairman, William L. Everitt, of the Engineering College Administrative Council July 1, 1954—July 1, 1955

Executive Committee Meetings

This year the Executive Committee held one meeting which was on November 17, 1954, during the Land Grant College meetings at Washington, D. C. At this, the 1955 Annual Meeting program was outlined and matters were subsequently handled by correspondence. Minutes of this meeting were circulated as Appendix I of Executive Committee Bulletin Number XVII of May, 1955.

A luncheon meeting of old and new members was held on June 23 at Pennsylvania State University to discuss plans for 1955–56.

Nominating Committee

At the November Executive Committee meeting, the following nominating committee was appointed by Chairman Everitt: W. G. Van Note, chairman; R. A. Morgen; E. W. Schilling and C. L. Wilson. Balloting on the slate proposed by the nominating committee resulted in the following elections for a term of two years:

Chairman, W. T. Alexander
Secretary, R. A. Morgen
Executive Committeemen, H. E. Wessman and J. R. Cudworth

Military Affairs Committee

In June this committee was requested by the ASEE Committee on Evaluation to make a survey of the ROTC situation, particularly with regard to net graduation credits earned through ROTC.

All deans of engineering were canvassed in September to determine (1) credit being granted for ROTC courses, (2) educational value of advanced courses in opinion of engineering educators, (3) experience with "General Military Science" where conversion from "Branch Material" programs had occurred. A complete report of this study will be published in the JOURNAL. This study indi-

cates that an average of 14.3 credit hours is allowed toward the B.S. degree. Figures published by the Army in February, 1955 show slightly higher figures of 15.9 credit hours.

In March, 1955, the chairman requested a statement of Army policy toward conversion of ROTC units from Branch Material to Branch General from General P. F. Linderman, Chief, Army Reserve and ROTC Affairs. General Linderman replied, "The choice between the two programs continues to be voluntary on the part of the institutions concerned."

Selection and Guidance Committee

The two major projects of this committee for the year were:

1. To maintain contact with the research being carried on by the Educational Testing Service to develop a placement test for engineering graduates.
2. To develop a list of books germane to engineering and suitable for the guidance of high school students.

Placement Test Research. This project has continued from a start last year under the sponsorship and with the cooperation of five companies: The Bell Systems, Detroit Edison, B. F. Goodrich, IBM and Westinghouse. The hope that other companies would participate has not yet materialized. A more detailed progress report on this research was made at the June 20 ASEE General Session.

After study, the initial division of young engineers four to seven years after graduation into Research, Design, Manufacturing, Sales and Supervision was abandoned in favor of the following functional groups:

Technical Engineering

1. Research Engineering
2. Applications Engineering
3. Design Engineering
4. Product Engineering

Administrative Engineering

5. Operations Engineering
6. Supervisory Engineering
7. Sales Engineering

"The labels here attached to the seven groups do not necessarily conform to normal engineering usage. . . . The groups are defined by the ranking-in-importance of the unit activities, and these ranks also define the labels as far as the present context is concerned. Any reader who disagrees with one or more labels is free to substitute on his own, without otherwise affecting the results or discussion," said Dr. D. R. Saunders.

Preliminary work indicated two main conclusions:

1. "The difference among engineering jobs, for engineers having five to seven years of post graduation experience, are much greater within companies than between companies."
2. "The differences as observed in one company tend to parallel the differences as observed in another company, although not all functional groups are represented in every company."

Early in 1955, after preparation and evaluation of the test battery the tests were administered to 1929 young engineers at 50 locations in the U. S. and Canada. From the 1929 engineers tested, 800 were included in a sample for analysis and a total of 56 scores were obtained from each.

In view of the relatively high levels of confidence and statistical significance observed in the scores, a cross validation with an additional sample is not highly important.

Preliminary inspections suggest that the tests can differentiate functions generally, predict success ratings generally, or predict membership or success in particular functions.

Further work is progressing to produce the last battery that can be made available for testing newly hired engineers.

A book list, prepared previously, was discussed on a June 21 committee meeting.

Secondary Schools Committee

This committee has continued its efforts further to improve the study of college-high school cooperation. Particular attention has been directed to the following:

Guidance. There is continuing need to direct more and better prepared students into the colleges of engineering. Engineering schools should continue and expand their guidance work through direct association with secondary schools, through alumni groups, and in cooperation with technical societies.

In the opinion of this group, ASEE should take an active part in preparing a guidance book which would tell more of the actualities of an engineering education in college. This would supplement the existing pamphlets, and be written in general terms for distribution through engineering schools. Individual schools could supplement the basic guide with specific information about their schools. This committee recommends that ASEE consider supporting a project to prepare such a guidance booklet.

Future Engineer's of American Clubs. These clubs exist in some high schools and have much merit. It is recommended that the formation of these clubs in high schools be promoted by engineering schools in cooperation with the technical societies.

High School-College Articulation in Mathematics and Science. Considerable study indicates that the extreme difficulty involved precludes establishment of a nationwide program. It must be developed by the schools in each state. This program is well developed in Illinois and the information is available to other states.

Cooperation with Secondary Schools. Only harm can result from a critical and superior attitude toward the secondary schools. A program of friendly cooperation and helpfulness is the only hope of elevating the secondary school standards, with a resulting elevation of the level of instruction in the engineering schools.

Industrial Scholarship Committee (ad hoc)

At the 1954 meeting for Institutional Representatives, the following vote was passed: "The Chairman appoint an *ad hoc* committee to investigate the propriety and necessary mechanism for ASEE to act as a clearing house for industrial scholarship funds."

In compliance with this vote, Dr. R. A. Morgen was appointed chairman and preliminary investigations are in progress. This committee made a detailed report at the Annual Meeting.

Manpower Committee

A definite report is difficult as major legislation affecting manpower was held up in the House of Representatives. Widespread sentiment for more *selective* processes in induction and utilization by armed forces waits for final word from the Congress.

The Selective Service situation appears to be unchanged, including a tightening of graduate deferment requirements. The ROTC situation is unclear, but the program seems stabilized numerically, and may have more technical flavor.

In currently proposed legislation, it is provided that men educated in critical disciplines will be able to enter their specialty after six months of military training and service as compared to the present 24 months requirement.

Increasingly widespread awareness of the importance of technology and recent information concerning education in Russia should result in better utilization of specialized talents for the common good.

ASEE should continue full support and assistance to the Engineering Manpower Commission. A recognized spokesman for engineering is and has been of signal importance.

Foreign Operations Administration Committee

This committee was formed to advise and assist the Foreign Operations Admin-

istration as needed, particularly in personnel matters.

Although the chairman has met with Dr. Andrews of FOA several times and certain committee members have served individually, FOA has increasingly contracted its technical, educational, and research problems with a broad group of universities. Consequently, the committee, as such, has not been asked for assistance during the year.

In view of this situation, it is recommended that this *ad hoc* committee be discontinued and its functions transferred to the International Relations Committee.

International Relations Committee

In general the work of this committee has been directed to contacting as many educators from other countries who might be in this country at the time of the Annual Meeting as is possible. Also to be sure that they will be warmly welcomed if they attend the ASEE meeting.

In many cases opportunities for building good will are lost through the lack of a special effort to be hospitable to educators from other lands. The impressions gained from personal relationships last for many years and can do much good or much harm.

News Bulletins

ECAC Executive Committee Bulletins were circulated to the membership and to the ASEE officers and council members twice during the year.

ASEE Meetings at Michigan State University

Executive Board, Sunday, November 13, dinner meeting at 6 p.m.

General Council, Monday, November 14, dinner meeting at 6 p.m.

ECAC Executive Committee, Tuesday, November 15, breakfast meeting at 7:30 a.m.

ECRC Executive Committee, Tuesday, November 15, luncheon meeting at noon.

Report of the Resolutions Committee June 23, 1955

The Committee on Resolutions recommends the adoption by the Society of the following statement:

The American Society for Engineering Education wishes to express its sincere thanks to the many people who have generously contributed so many thousands of man and woman-hours of intelligent planning and devoted work toward making this, our 63rd Annual Meeting, one of the most notably successful and enjoyable in our history.

Our thanks are extended to the national and divisional officers and committees, the General Council, the Administrative and Research Councils, and the many speakers, all of whom have taken time out of busy lives to freely and generously render invaluable services to the Society.

Especially, we wish to express our most sincere appreciation to the members of The Pennsylvania State University Branch of The American Society for Engineering Education, their wives and their children, who have been responsible for the local arrangements which have contributed immeasurably to the smooth operation of all segments of the program, and to our comfort and convenience.

The efficient and painless registration process, the more than adequate provisions for our housing and sustenance, the entertainment features provided for us, and for our wives and our children, and the eagerness with which our needs and desires have been met, all combine to create a warm spot in our hearts for Penn State.

We are grateful to the University for inviting us to participate in its One Hundredth Anniversary celebration. We congratulate the University on her achievements during her first hundred years, and predict that the next hundred years will be equally successful.

The American Society for Engineering Education hereby directs that this statement be spread upon the official minutes of the Society, and that copies be sent to

President Milton S. Eisenhower
The Pennsylvania State University Branch of The American Society for Engineering Education
Dean Eric A. Walker

Committee: Frank Groseclose, Georgia Institute of Technology
Frank Kerekes, Michigan School of Mining and Technology
Henry H. Armsby, (Chairman) U. S. Office of Education

Officers of Divisions, Sections and Committees 1955-56

DIVISIONS

AERONAUTICAL: J. W. Hoover, Chairman, University of Florida

AGRICULTURAL: F. A. Kummer, Chairman, Alabama Polytechnic Institute

ARCHITECTURAL: L. A. Richardson, Chairman, Pennsylvania State University

CHEMICAL: H. P. Simons, Chairman, West Virginia University

CIVIL ENGINEERING: R. L. Peurifoy, Chairman, A. & M. College of Texas

COOPERATIVE ENGINEERING EDUCATION: R. G. Owens, Chairman, Illinois Institute of Technology

EDUCATIONAL METHODS: F. K. Kraybill, Chairman, Duke University

ELECTRICAL: W. C. Johnson, Chairman, Princeton, N. J.

ENGINEERING DRAWING: W. E. Street, Chairman, Texas A. & M. College

ENGLISH: T. H. Farrell, Jr., Chairman, State University of Iowa

EVENING ENGINEERING EDUCATION: K. W. Riddle, Chairman, Drexel Institute of Technology

GRADUATE STUDIES: N. A. Hall, Chairman, University of Minnesota

HUMANISTIC-SOCIAL: W. K. Brown, Chairman, Rensselaer Polytechnic Institute

INDUSTRIAL ENGINEERING: J. R. Huffman, Chairman, University of California, Los Angeles

MATHEMATICS: H. Reingold, Chairman, Illinois Institute of Technology

MECHANICAL: B. T. McMinn, Chairman, University of Washington

MECHANICS: H. F. Marco, Chairman, Air Force Institute of Technology

MINERAL ENGINEERING: C. O. Frush, Chairman, Iowa State College

PHYSICS: D. Loughridge, Chairman, Northwestern University

RELATIONS WITH INDUSTRY: W. Burton, Chairman, Minnesota Mining and Manufacturing Co.

TECHNICAL INSTITUTE: K. Werwath, Chairman, Milwaukee School of Engineering

SECTIONS

ALLEGHENY: J. W. Graham, Jr., Chairman, Carnegie Institute of Technology

ILLINOIS-INDIANA: O. W. Witzell, Chairman, Purdue University

KANSAS-NEBRASKA: R. M. Kerchner, Chairman, Kansas State College

MICHIGAN: G. H. Howell, Chairman, Wayne University

MIDDLE ATLANTIC: C. C. Carr, Chairman, Pratt Institute

MISSOURI-ARKANSAS: J. B. Macelwane, Chairman, St. Louis University

NATIONAL CAPITAL AREA: D. C. Jackson, Jr., Chairman, Aberdeen Proving Ground

NEW ENGLAND: E. R. McKee, Chairman, University of Vermont

NORTH MIDWEST: L. L. Amidon, Chairman, South Dakota State College

OHIO: E. C. Clark, Chairman, Ohio State University

PACIFIC NORTHWEST: J. B. Morrison, Chairman, University of Washington

PACIFIC SOUTHWEST: R. G. Moses, Chairman, Pasadena City College

ROCKY MOUNTAIN: W. H. Parks, Chairman, University of Denver

SOUTHEASTERN: D. W. Dutton, Chairman, Georgia Institute of Technology

SOUTHWEST: H. K. Bone, Chairman, University of Oklahoma

UPPER NEW YORK-ONTARIO: B. H. Norem, Chairman, Syracuse University

COMMITTEES

ANNUAL MEETING: L. J. Lassalle, Chairman, Louisiana State University

ASSOCIATE INSTITUTIONAL MEMBERSHIP: G. D. Lobingier, Chairman, Westinghouse Electric Corp.

ATOMIC ENERGY EDUCATION: P. N. Powers, Chairman, Monsanto Chemical Co.

CONSTITUTION AND BY-LAWS: C. A. Brown, Chairman, General Motors Institute

DEGREE DESIGNATION IN COLLEGES OF ENGINEERING AND TECHNICAL INSTITUTES: J.

H. Sams, Chairman, Clemson Agricultural College

DIVISIONS AND CURRICULAR COMMITTEES: L. J. Lassalle, Chairman, Louisiana State University

ENGINEERING ECONOMY: A. E. Gruehr, Chairman, Consolidated Edison Co.

ENGINEERING SCHOOL LIBRARIES: J. H. Moriarty, Chairman, Purdue University

ETHICS: C. J. Freund, Chairman, University of Detroit

FINANCIAL POLICY: W. R. Woolrich, Chairman, University of Texas

GEORGE WESTINGHOUSE AWARD: R. S. Paffenberger, Chairman, Ohio State University

GRADUATE STUDY PROJECT (Ad Hoc): E. Weber, Chairman, Polytechnic Institute of Brooklyn

HONORARY MEMBERSHIP: M. S. Coover, Chairman, Iowa State College

HUMANISTIC-SOCIAL RESEARCH PROJECT: E. S. Burdell, Chairman, The Cooper Union

JAMES H. MCGRAW AWARD: H. R. Beatty, Chairman, Wentworth Institute

JUDGES FOR YET PAPER CONTEST: W. H. Crater, Chairman, Newark College of Engineering

LAMME AWARD: C. L. Eckel, Chairman, University of Colorado

MEMBERSHIP: J. L. Artley, Chairman, Johns Hopkins University

NOMINATING: W. R. Woolrich, Chairman, University of Texas

PUBLICATIONS: W. L. Collins, Chairman, University of Illinois

RECOGNITION AND INCENTIVES FOR GOOD TEACHING: R. W. Schmelzer, Chairman, Rensselaer Polytechnic Institute

SECTIONS AND BRANCHES: B. R. Teare, Jr., Chairman, Carnegie Institute of Technology

SOCIETY FUNCTIONS: B. R. Teare, Jr., Chairman, Carnegie Institute of Technology

TEXTILE ENGINEERING: R. Carson, Chairman, Clemson College

YOUNG ENGINEERING TEACHERS: J. L. Artley, Chairman, Johns Hopkins University

New Members

ARMANTROUT, GUY E., Teacher of Engineering-Technology, Pasadena City College, Pasadena, California. Walter L. Johnson, Robert G. Moses.

BARKO, JAMES S., Professor and Head of Graphics Department, USAF Academy, Aurora, Colorado. Archie Higdon, J. C. Hempstead.

BENSON, ROLAND A. H., Conference Leader —Distribution Training, General Motors Institute, Flint, Mich. Harold M. Dent, Earl D. Black.

BOGAN, CHARLES W., Assistant Professor of Architecture, Catholic University of America, Washington, D. C. Herbert Mannucia, Joseph C. Michalowicz.

BUCHTA, J. WILLIAM, Professor of Physics, University of Minnesota, Minneapolis, Minn. Raymond J. Seeger, G. H. Hickox.

CARTER, ARCHIE N., Manager of Highway Division, The Associated General Contractors of America, Inc., Washington, D. C. R. L. Peurifoy, Arthur J. McNair.

CASE, LLOYD N., Vice President and Dean of Men and Head of Structural Design Department, Cogswell Polytechnical College, San Francisco, California. E. W. Smith, Robert W. Dodd.

CHENG, DAVID K., Professor of Electrical Engineering, Syracuse University, Syracuse, New York. Norman Balabamion, Wilbur R. LePage.

COE, EDWARD H., Assistant Professor of Civil Engineering, University of Illinois, Navy Pier, Chicago 11, Ill. M. V. J. Dembski, Harold R. Goppert.

CRONIN, JUSTIN C., Acting Chairman of the Department of Industrial Management, Boston College, Boston, Mass. Joseph V. D'Avilla, Paul O'Donnell.

CURRAN, T. BAILEY, Head of Chemistry Department, Bridgeport Engineering Institute, Bridgeport, Conn. Arthur E. Keatz, Stanley R. O'Meara.

DREIER, THEODORE, Manager of Engineering Development, Clock and Timer Department, General Electric Company, Ashland, Mass. A. M. Anderson, M. M. Boring.

ELLER, ERNEST M., Director of Engineering, Bucknell University, Lewisburg, Pa. George A. Irland, K. L. Holderman.

FURLIN, LOUIS JR., Instructor in Technical Department, Central Technical Institute, Kansas City, Missouri. C. L. Foster, N. E. Vilander.

HALLIDAY, DAVID, Head of Department of Physics, University of Pittsburgh, Pittsburgh, Pa. R. C. Gorham, Philip E. Rush.

HARTJE, GEORGE F., Instructor in Industrial Engineering, Purdue University, Lafayette, Indiana. John M. Hayes, L. T. Wyly.

HEHNER, HARRY OMAR, Assistant Manager Technical Recruiting, Monsanto Chemical Company, St. Louis, Mo. R. M. Oliver, Gerald Nadler.

HENDERSON, PHILIP H., Placement Representative, Employee Relations, E. I. du Pont de Nemours and Company, Wilmington, Del. C. B. Hill, J. G. Buckley.

HENDRICKSON, JOE R., Professor of Applied Mechanics, Vanderbilt University, Nashville, Tenn. Fred J. Lewis, Bruce Boyer.

HERALD, CHARLES A., Instructor in Engineering Extension, The Pennsylvania State University, University Park, Pa. J. O. Harring, V. E. Neilly.

HUGGINS, WILLIAM H., Professor of Electrical Engineering, Johns Hopkins University, Baltimore, Maryland. John L. Artley, J. T. Thompson.

HUTCHINSON, JOHN W., Instructor in Civil Engineering, University of Illinois, Urbana, Ill. Jamison Vawter, Ellis Danner.

JONES, WINTHROP G., Instructor in Engineering, Central Technical Institute, Kansas City, Mo. C. L. Foster, N. E. Vilander.

KOENIG, J. FRANK, Assistant Professor of Electrical Engineering, Duke University, Durham, North Carolina. Edward K. Kraybill, Harry A. Owen, Jr.

KRANZBERG, MELVIN, Associate Professor of Social Studies, Case Institute of Technology, Cleveland, Ohio. F. H. Vose, Wm. W. Aubriton.

KRIEGER, HARRY, JR., Manager, Camden Engineering Personnel, Radio Corporation of

America, Camden, New Jersey. W. Leighton Collins, S. H. Pierce.

LEFLER, GLENN Q., Head and Professor of Physics, Eastern Illinois State College, Charleston, Ill. C. E. Bennett, W. Leighton Collins.

MORRIS, CHARLES, Instructor of Engineering Mechanics, New York University, New York, N. Y. F. L. Singer, Wm. G. Plumtree.

MORTON, WALTER B., Assistant Electrical Engineer, Pennsylvania Power and Light Company, Allentown, Pa. N. S. Hibshman, Allen P. Richmond, Jr.

MOYER, RICHARD L., Assistant Professor of Mechanical Engineering, University of Delaware, Newark, Del. H. L. Bueche, James I. Chower.

MCCLURE, JAMES D., in service (formerly Teaching Assistant of Department of Applied Mechanics, University of Kansas), Fort Knox, Ky. Kenneth C. Deemer, G. W. Bradshaw.

MCELRATH, GAYLE W., Associate Professor in Industrial Engineering Division, Mechanical Engineering Department, University of Minnesota, Minneapolis, Minn. A. C. Jordan, Adolph O. Lees.

MCKINNON, GORDON J., Staff Assistant, Operations Staff, Michigan Consolidated Gas Company, Detroit, Michigan.

PAULSON, FREDERICK H., Partner and Manager of Consulting Engineers, C. A. Maguire and Associates, Providence, Rhode Island. F. W. Stubbs, Jr., T. S. Crawford.

PENA, ISIDRO R., Professor of Chemical Engineering, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico. Juan H. Sanchez, A. C. Soler.

PERKINS, THEODORE M., Head of Mechanical Engineering Department, Bridgeport Engineering Institute, Bridgeport, Conn. Arthur E. Keating, Stanley R. O'Meara.

REID, ROBERT C., Assistant Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. H. F. Johnson, E. E. Pilkentreat.

RICHMOND, WILLIAM OSBORN, Head, Department of Mechanical Engineering, University of British Columbia, Vancouver, B. C. L. S. Pauchland, M. Pouches.

ROBINSON, JOHN A., Secretary of Bridgeport Engineering Institute, Bridgeport, Conn. A. Keel, Stanley R. O'Meara.

ROONEY, WALTER R., Chief, Engineering Education, National Security Agency, Washington, D. C. Sydney B. Ingram, J. G. Wohlford.

SCOTT, PEARL A., Instructor in Central Technical Institute, Kansas City, Mo. C. L. Foster, N. E. Vilander.

SELLON, WILLIAM A., Assistant Professor of Industrial Arts, Ohio University, Athens, Ohio. E. J. Taylor, Paul H. Black.

SHAH-NAZAROFF, LEONID G., Assistant Professor of Civil Engineering, Drexel Institute of Technology, Philadelphia, Pa. N. W. Blakeslee, C. L. Bachman.

SMETHERS, JOHN W., Assistant to Director of Engineering Evening School, Georgia Institute of Technology, Atlanta, Ga. M. M. McClure, R. S. Howell.

SMITH, HARRY C., Director of Education and Training, United States Steel Corporation, Pittsburgh 30, Pa. W. P. Jones, W. Leighton Collins.

SOELLNER, ROY O., Instructor of Technical Department, Central Technical Institute, Kansas City, Kansas. C. L. Foster, N. E. Vilander.

STEINBERG, MAX J., Division Engineer of Consolidated Edison Company of N. Y. Incorporated, New York. Anatole R. Gruebe, H. F. Roemmele.

STOCKEL, IVAR H., Assistant Professor of Mechanical Engineering, U. S. Naval Postgraduate School, Annapolis, Md. Arthur E. Bock, L. R. Mann.

SULLIVAN, THOMAS E., Director of Pre-Engineering Department, Rockhurst College, Kansas City, Mo. Ross R. Heinrich, Victor J. Blum.

SWEIGERT, RAY L., JR., Graduate Assistant in English (technical writing), Georgia Institute of Technology, Atlanta, Ga. R. L. Sweigert, W. D. Jones.

TAYLOR, CHARLES E., Assistant Professor of Theoretical and Applied Mechanics, University of Illinois, Urbana, Ill. Clyde E. Kesler, W. Leighton Collins.

WARREN, RICHARD, Chairman of Physics, Michigan College of Mining and Technology, Houghton, Michigan. Glenn O. Lefler, W. Leighton Collins.

WATSON, RAYMOND C., JR., Instructor in Department of Engineering, Jacksonville State College, Jacksonville, Fla. Charles P. Hayes, Joseph A. Bennett.

WEGER, ERIC, Assistant Professor of Chemical Engineering, The Johns Hopkins University, Baltimore, Maryland. Robert H. Roy, H. E. Hoelscher.

WELCH, HOMER W., JR., Associate Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. William Kerr, S. S. Attwood.

WILLIAMS, LEO, JR., Professor of Electrical Engineering, Prairie View A. and M. College, Prairie View, Texas. J. M. Graham, C. L. Wilson.

ZOERB, GERALD C., Assistant Professor of Agricultural Engineering, South Dakota State College, Brookings, S. D. Dennis L. Moe, H. H. DeLong.

57 new members this list
54 previously added

111 new members this year

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, University of Illinois, Urbana, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

AERODYNAMICS OR FLUID MECHANics position open for undergraduate and graduate teaching. Desires man who either is, or will be, an outstanding teacher for both undergraduate or graduate courses. Man must have proven ability for research and publication. Subsonic and supersonic research facilities available. Advanced degree required. Rank and salary open. Please forward complete details of education, experience and personal background to Chairman, Department of Aeronautical Engineering, University of Detroit, Detroit 21, Michigan.

EXCELLENT OPPORTUNITY OPEN for an assistant or associate professor in a Southeastern University to develop graduate study in Soil Mechanics and to take charge of undergraduate work in same field. Salary for nine-month academic year. OCT–1

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute of Technology	April, 1956	J. W. Graham, Jr., Carnegie Institute of Technology
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	R. M. Kerchner, Kansas State College
Michigan	Wayne University	May 6, 1956	G. H. Howell, Wayne University
Middle Atlantic	New York University	Dec. 3, 1955	C. C. Carr, Pratt Institute
Missouri-Arkansas	St. Louis University	April 7, 1956	J. B. Macelwane, St. Louis University
National Capital Area	Capital Radio Engineering Institute	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	University of Maine	Oct. 8, 1955	E. R. McKee, University of Vermont
North Midwest	South Dakota State College	Nov. 4–5, 1955	L. L. Amidon, South Dakota State College
Ohio	Ohio State University	April 28, 1956	E. C. Clark, Ohio State University
*Pacific Northwest			J. B. Morrison, University of Washington
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1955	R. G. Moses, Pasadena City College
*Rocky Mountain	Denver University		W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 14–15, 1955	B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No Date Set.

Do You Know—

► A special letter from the Treasurer was enclosed with all dues statements sent to those who were delinquent. The number delinquent seemed unduly large and the number to be dropped for non-payment of dues for two or more years looked as though it would increase greatly. The Executive Board and the Financial Policy Committees approved the procedure at the Annual Meeting. It also seemed as though many were terminating affiliation with the Society by discontinuing their dues payments instead of resigning. Following the latter method simplifies the work in the Secretary's office and is preferred. The letters sent also afforded an opportunity to check the correctness of some of our records.

► The Constitution and By-Laws of the Society state, "An individual member who has been in good standing for twenty-five (25) years or more, who has reached the age of sixty-five (65) years, and who has retired from active professional life, may, upon written request, be designated as a life member by vote of the General Council, and shall thereafter be exempt from payment of dues." Long-time, loyal members should request such status instead of resigning. Many members do wish to continue their financial support of the Society after their retirement and to them we are indeed grateful. We try to prevent resignations of long-time members by calling their attention to the life membership provisions, but we can't be sure we catch everyone, particularly if they just stop paying dues and say nothing to us.

► All of you received the Yearbook Information Card in September. Did you return it? Did you inform us of your change of address and change of title? The correctness of addresses and titles are important aspects of the Yearbook information and if *you* don't send them to us the value of the Yearbook is lessened. *Maybe* we can still get a change made if you hurry, but remember we want the February Yearbook issue to come out in February and can't wait for many late changes.

► At the Annual Meeting ECRC was granted permission by the General Council to establish an annual award for outstanding research. The first award will be made at the 1956 Annual Meeting. A gift from outside ASEE is being sought for the award, but pending such a grant the necessary funds will come from the ECRC reserve fund. The award is to consist of a gold medal and a certificate. As soon as details of the method of selection, etc. are determined they will be published. This award appropriately fits into the pattern of the other Society awards—Lamme, Westinghouse, and McGraw.

► The General Council also granted ECRC approval to seek funds from the National Science Foundation for a study to determine the research needs of the engineering sciences and the ways by which they shall be met. Most of the other branches of science have made or are making such studies and it is appropriate for engineering to make the same type of study. It is to be an ASEE project covering a two-year period of time and costing $40,000. The work will be directed by ECRC personnel and, among other things, will consist of visits to universities and research laboratories.

► In the October issue of the JOURNAL there were brief announcements about the Lamme, Westinghouse and McGraw awards. Preparing adequate material to accompany a nomination requires much time and effort. If you have a candidate for an award in mind, active work on the collection of material should begin now. The committees making the selections have an unenviable task and their decisions aren't always easy to make. We should cooperate by having all material in good condition and submitted as early as possible.

► All YETs should begin thinking about their paper contest. Each Section chooses a winner and their papers are then judged by the national judging committee. Last year a few sections did not submit a paper! That is most unfortunate and shouldn't happen again. Section officers and deans, as well as YET organizations, should promote participation. The first place winner receives $200 and second place $100. There also is an honorable mention. The awards are made at the Annual Banquet, the winning papers are presented at the Annual Meeting, and the winners' institutions are requested to pay their expenses to the Annual Meeting. In addition, all papers submitted for the national competition are considered for publication in the JOURNAL OF ENGINEERING EDUCATION.

► Questions are frequently asked about Section and committee chairmen. The former are listed in each issue of the JOURNAL on the Section Meetings page; the latter always appear in the October issue of the JOURNAL. The representatives on the General Council and the officers of the Society always are listed on page two (2) of each JOURNAL. It is hoped a complete list of ASEE committee members will appear in the December JOURNAL in addition to the February Yearbook issue.

► The minutes of the meetings of the Executive Board and General Council are on pages 290 and 294. These are essentially as they appear in the records of the Society, except that most of the committee reports attached as appendices are not included. Most of these reports are being published separately in order to attach appropriate significance to their contents.

► The initial printing of 1000 Educational Aids is sold out. A second printing of 1000 is now available—so, send in your dollar and you'll get your copy. Also, is there a need for another volume covering other branches of engineering? You who are doing the actual teaching must determine this need. Some money is available for additional work. As soon as the need and the desire are indicated the Executive Board will appoint a new committee.

► Plans are being developed for four Summer Schools for 1956. The Divisions sponsoring them are Civil Engineering, Drawing, Humanistic-Social, and Mechanics. All are being planned for about the time of the Annual Meeting. The continued desire for these schools during the past few years indicates their value and the desire of those in the particular areas of engineering to get together and seriously "talk shop" about common problems and practices. Every Division could profitably devote a summer school to a consideration of the report on Evaluation of Engineering Education.

► The Relations With Industry Division is holding its annual College-Industry Conference at Marquette University on January 25 and 26. The theme of the meeting will be "The Humanistic-Social Approach as an Aid to Engineering." Marquette is celebrating its 75th anniversary and the holding of this Conference is part of their celebration. This meeting is becoming more important each year; there is no doubt about the growing interest of industry in education.

► Plans are being made to ask all Sections to publicize the 1956 Annual Meeting at Iowa State at their meetings. It is hoped the Section officers and host institutions will cooperate with Lowell O. Stewart and his committee at Iowa State. This is a step in the coordination of Section Meetings and the Annual Meeting, something which seems desirable. *"Aim for Ames in '56"* for the week of June 25–29!

► Don't forget about the "Nuclear Engineering and Science Congress" at Cleveland, Ohio on December 12–16. Engineers Joint Council, of which ASEE is a participating society, is coordinating the efforts of 26 Engineering and Scientific Groups interested in the subject. 292 technical papers will be presented. See page 268 for more details.

W. LEIGHTON COLLINS
Secretary

Humanistic-Social Stem in Engineering Education Bibliography

The staff of the Cooper Union Library has prepared a completely revised and more comprehensive edition of the bibliography, *The Humanistic-Social Stem in Engineering Education.* Chronologically, the bibliography cover this area from 1876 through May, 1955. It is especially applicable to the fields of chemical, civil, electrical, and mechanical engineering. One complimentary copy of the bibliography will be sent to each ASEE member who will tear off and complete the form below and send it to Joseph N. Whitten, Librarian, The Cooper Union, Cooper Square, New York 3, New York.

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Please send me a copy of the 1955 revised edition,
The Humanistic-Social Stem in Engineering Education.

Name ..... Title .....

Address .....

.....

PROFESSOR EDWIN C. MCCLINTOCK

Meet Professor Edwin C. McClintock, New Journal Editor

Professor Edwin C. McClintock will succeed Professor C. E. Watson as Editor of the JOURNAL OF ENGINEERING EDUCATION effective October 1, 1955. His appointment fills the gap left by the untimely death of Professor Lisle A. Rose, who was to have been the new editor. Due to the long-range production schedule of the JOURNAL, Professor Watson will plan and supervise all issues of the JOURNAL through the December, 1955 issue. Professor McClintock's editing will begin with the January, 1956 JOURNAL.

The new editor, formerly on the faculty of the University of Virginia, recently accepted an appointment at the University of Illinois as Professor of General Engineering, Director of Engineering Information and Publications, and Engineering Experiment Station Editor. Professor McClintock will spend one-fifth of his time as editor of the JOURNAL and four-fifths of his time on his other duties.

Professor McClintock was born February 3, 1914, at Monterey, California. His family moved to the East where he received his early education in Washington, D. C., schools. He earned his B.A. at the University of Virginia, majoring in literature, speech, and social theory. He continued with graduate studies at the University of Virginia.

In 1939, he was married to Elizabeth Kepner of Charlottesville, Virginia. They have two sons, Richard Clare, 11, and Robert White, 8.

In 1940, after holding concurrent part-time instructorships in speech and English, Professor McClintock was appointed instructor in English in the unique humanities program for the School of Engineering at the University of Virginia. He rose to Acting Professor and Acting Head of the Department of English in the School of Engineering in 1951. He was in charge of editing catalogues and official publications for the University for several years. After training at the Library of Congress, he was placed in charge of developing and administering an engineering and science-technology library at the University.

After joining the ASEE in 1939, he became active in the English and Social-Humanistic Divisions. He has been a member of the Engineering School Libraries Committee and is a member of the Publications Committee. He is a member of Phi Beta Kappa, Omicron Delta Kappa, and Delta Sigma Rho. His professional connections include the Special Libraries Association, American Library Association, Association of Special Libraries, American Business Writers Association, College English Association, Society of Professional Writers and Editors, and Illuminating Engineering Society.

Among his publications are papers on training scientists and engineers for industrial and special library techniques, research resources of British metallurgical libraries, and two books (in the process of publication) on grammar, composition, and advanced scientific writing and speaking.

Professor McClintock has been concerned with the development of humanities courses in engineering schools, with the encouragement of secondary school interests in science or technology, and with improved methods of guidance for science-minded school or college students. He has been active in the Junior Academy of Science work in Virginia and chairman of the State Science Talent Search. With J. L. Vaughan, another ASEE member, he recently developed a pioneer course for secondary school teachers exploring scientific resources and communications methods helpful to science teaching in secondary schools.

Education for Research in Industry*

By CHALMER G. KIRKBRIDE

President, Houdry Process Corporation, Philadelphia, Penna.

Before we get involved in trying to determine what should be done to prepare the young engineer for industrial research, let us review briefly the history of the development of industrial research. Then let us consider what qualities we would like to develop in the embryo researcher.

What is research? There are many millions of dollars spent each year on work that is classified by some as industrial research, but I would not so classify it.

Research is defined by Webster as diligent, studious inquiry or examination in seeking new facts or undiscovered principles. This is good but I would want to stipulate also that research is done in the mind rather than in the laboratory or library. It is a mental attitude that distinguishes it from mere scientific or technical work. Experimental work is done in research merely to assist and verify.

The use of the experiment to assist in research was scorned by the Greek philosophers. At that time the intellectuals preferred to accept some untested and even invalid premise as a basis from which one could philosophize to the construction of completely new systems without the aid of experiment. Experiment was scorned because that was likened to the practice of slaves. The acceptance of experiment as an aid was, therefore, too much for the intellectuals at that time. Without trying to be facetious, I suspect that another reason for scorning the experimental method may have been that the intellectuals did not want their theoretical conclusions confused by the facts. I might say that even today there are many pseudo researchers of that attitude who classify themselves as intellectuals.

It was not until near the end of the sixteenth century before the experimental method was adopted as an aid in the study of nature. Galileo and Francis Bacon perhaps were the first to advocate the use of experimental methods in research. During the past three and a half centuries the use of experimentation in research has developed at a phenomenal rate.

Prior to the early part of the twentieth century, industrial research was almost non-existent. It was carried on by individual inventors. But after World War I, industrial research developed exponentially with time. Furthermore, this growth has taken the direction of organized research in which investigations are conducted by teams of inventors or researchers as opposed to individuals.

Accomplishment by team-work far exceeds that attainable by a like number of individual investigators of equal competence. Of course, thinking is individual in nature but it is catalyzed by team effort if the team is managed properly. With proper management, a closely knit team can be developed, the members of which stimulate creative thinking in each other toward a common objective. Unless this is attained, the group will work as separate individuals that do not catalyze each other.

Since research is done in the mind rather than in the laboratory, it is essential that all conditions be favorable to the stimulation of team effort. Worried minds are not productive in research.

* Presented at the General Session, Annual Meeting of ASEE, Penn State University, June 22, 1955.

Now, let us consider the qualities desired in the young engineer entering industrial research. Immediately we can conclude from the discussion thus far that he should have the ability to work in cooperation with others. One of the problems often encountered with the young graduate is to fit him into a team with other highly trained engineers and scientists. Too often, his training in school has neglected the development of his ability to work in a team.

Also, too often, his training in school has been too much in the direction of robot intellectuality—too much standardization, too much devotion to the assimilation of factual knowledge at the expense of learning how to think imaginatively. It is unfortunate that we have not been able to avoid the repression of imagination and ingenuity of students in our mass educational methods. Mass education processes are based on classifying students into groups and if a chap happens not to fit into one of these groups he often is labeled as stupid and cast by the wayside even though he may be highly intelligent. This process of repressing the student's imagination and ingenuity is started in grammar school and continues through secondary school and into college work. It is one of the unfortunate faults of mass education methods.

The present day graduate is strong in being able to carry out a mathematical solution to a problem after the problem has been defined for him. But he is pitifully weak in recognizing and defining the limits of a problem. He could stand considerable strengthening in this regard.

As other desirable qualities in the young engineer, he should have the ability to study and in addition let us hope that he has developed the habit of studying.

He should be of high integrity. He should be courageous. He should have self-confidence. He should have energy. He should be determined. He should have a deep sense of responsibility. He should be able to think creatively.

But the most desirable quality of all is sound judgment. Some are born with this quality, but most people must develop it if they ever get it at all.

Yes, all those qualities are desirable for our young graduate entering industrial research. However, these same qualities are desirable for the young engineer entering almost any other field of engineering practice. Hence, I come to the conclusion that the student should not be trained specifically for industrial research. Of course, the aptitude of the young man for industrial research must be favorable but that is another matter.

I want to make it clear, then, that I am opposed to any educational program that attempts to prepare an engineer for a specific niche in life. It is unfortunate that the interests of so many students are encouraged only down narrow paths so that in effect they are led into ruts from which many of them never emerge. Other interests these students may have had are too often allowed to go undeveloped and finally to die.

It is essential, in my opinion, that the student be trained so that he may enter his professional practice with a maximum of self-confidence and courage. A broad intensive training is needed because the young engineer will not be able to select the obstacles that fall in his path. He must be able to endure hardships and disappointments in his work because it is during periods of hardship that we learn the most. We must be conditioned by hardships to prepare us for greater responsibilities.

Hence, what I have to say about the academic training needed to prepare the young engineer for industrial research will be equally applicable to prepare him for many other fields of engineering practice.

Broad Training Proposed

A proper objective of education is first to develop well balanced men and women who not only are able to fit into society but also who have the ability to lead society. This objective is just as much a responsibility of engineering education

as it is of other branches of education such as law, literature, theology and journalism.

The engineer should not be trained specifically for industrial research. His education should not be given undue emphasis even though his immediate interests may lie in that direction.

It is true that research is a field for young men. On the average their ability to think creatively increases until the age of 25 to 30 years. Then it seems to level off for the next five to ten years. After that the decline in creativity takes place at an increasing rate.

Furthermore, the interest of the engineer in research seems to go through somewhat the same type of change. John Mills in his book, "The Engineer In Society," showed how the aptitude of the engineer for research declines as he gets older. If the total interests of the well adapted young research engineer is divided on the basis of a scale of 100 among ideas, things, people, and symbols it would be something like 60 for ideas, 25 for things, 10 for people and 5 for symbols. However, as the engineer grows older his interests change so that his greatest interest first turns to things, then to people and finally to symbols. Therefore, the young research engineer will probably pass on into other fields of enginering practice such as administration, design, construction, manufacturing, and sales. It would be unfortunate indeed if his education had not been sufficiently broad so as to be of value to him in these later endeavors.

The engineer should be given broad fundamental training which is applicable to all fields of engineering practice. The engineer of tomorrow must grapple with problems that the engineer of today has been unwilling if not unable to face. The engineer, together with his scientist counterpart, is primarily responsible for the creation of the American economy. Nevertheless, the modern engineer has devoted no significant effort toward directing this economy. He has been content to leave by default the job of directing to lawyers, labor negotiators, politicians, news commentators, economists, military leaders, and others who know less about his creation than he. The same type of mind that created the economy is needed to direct it. In the formation of our Republic, such men as Washington, Franklin and Jefferson were perhaps the outstanding leaders. These men had a knowledge of science and engineering as it existed at that time, in addition to a knowledge of law. And of greater importance they had the scientific approach to the solution of problems. The engineer of tomorrow must take a major share of the direct responsibility in directing the destiny of our Nation comparable to that taken by Washington, Franklin and Jefferson.

Training in Inductive Thinking Needed

The present day training given the student engineer, even through the doctorate, is concentrated (1) in the assimilation of factual knowledge, and (2) in the application of deductive logic. Rarely is any significant attention devoted to the application of inductive logic.

Now before going further, I want to make certain that you understand what I mean by deductive and inductive thinking. Deductive thinking is the process of reasoning from the general to the particular. Therefore, it involves reasoning from a general principle or law to a specific situation. Inductive thinking, on the other hand, is the process of reasoning from the particular to the general. Therefore, it involves reasoning on the basis of specific situations or random facts to a general principle or law.

As an example, the first, second and third laws of thermodynamics were arrived at by inductive thinking. They were established on the basis of countless observations of specific situations. There is no proof for these laws other than experience. However, once these laws are accepted the entire subject of thermodynamics is developed by use of deductive thinking. Inductive thinking is not infallible but the process of deductive thinking is rigorous. If a proposition is true

universally, it is true in any specific case. The maximum attainable by inductive reasoning, on the other hand, is only a high degree of probability. It is highly probable that the sun will rise and set tomorrow but we cannot prove that it will.

Even though inductive reasoning is not rigorous, it is an invaluable process of thinking in all fields of engineering practice, but particularly in the field of research. Inductive reasoning requires a great deal more applied imagination and ingenuity than does deductive reasoning. Inductive thinking has been ignored, relatively speaking, in our educational processes even though it has been the method of thinking by which general principles and laws of greatest import have been established. Its usefulness derives from the understanding that there are invariable effects produced by natural causes. Observation of these effects leads to discovery of apparent uniformities or relationships which provide the basis for establishing universal laws or general principles.

It was primarily deduction that helped to develop Euclidean geometry and the Scholastic philosophy. But it was induction that produced the Copernican system, Newton's principles of gravitation and motion, and Darwin's theory of evolution. The great scientists of the past who are recognized today were invariably masters at inductive thinking. I do not recall a single one that gained recognition by his ability at deductive reasoning. It was their inductive reasoning that distinguished them from the "run of the mill" scientist.

Perhaps it would be well at this time to determine why inductive reasoning has been given so little attention in education. Inductive reasoning is a method of thinking of free people. As long as education is to serve autocratic state or church rulers, there is no place or need for inductive reasoning. The general principles and laws will be determined, not by inductive reasoning, but by decree of the rulers.

The old Greek or Roman conception of education was to serve the state. In more modern times, Hitler and Stalin, among others, followed the same line.

In early Christian education, "catechumenal" and "catechetical" schools were established to teach and defend the dogmas of the church. However, at the end of the Middle Ages a new class of people came into being which was called merchants. They initiated vocational schools so that their children could follow their father's particular trades. Thus, appeared the guild and town schools with vocational rather than religious purposes. This radical change was introduced by the Renaissance challenging the church's control of education together with the Luther Reformation which proposed education for all the people and held that everyone should read and interpret the Bible "according to his own understanding."

At this point in the history of education, a place was made not only for deductive reasoning, attributed to Aristotle (384–323 B. C.), but also for inductive reasoning, attributed to Francis Bacon (1561–1626). Bacon understood the danger of prejudices, the value of scientific knowledge, and the necessity for clear and accurate thinking leading to hypotheses. Even so, there is reasonable doubt that he had any significant ability for inductive reasoning. His contemporary, Galileo, probably far excelled him at inductive reasoning but it was Bacon who had the influence on education and influenced it in the direction of inductive processes.

For the past three centuries, educators and philosophers have been trying to determine what should be taught in our schools and what are the principles of thinking. Fortunately, Bacon's basic ideas seem to have prevailed. Inductive reasoning in a free society appears *to be ready* for intensive development not only in the scientific and engineering fields but also in the political, social and economic life of the United States.

The engineer in research uses both deductive and inductive thinking. However, the differences between the creative abilities of individuals in research is reflected

probably more than anything else by the differences in their abilities to use inductive reasoning. The most creative may not be the strongest at deductive thinking nor the best posted in factual knowledge but he will surpass all others at inductive reasoning.

In research the engineer often employs unfounded hypotheses to assist him in his creativity. He makes observations of end results and he often tries to determine the path that was followed in reaching these end results. By using inductive reasoning with applied imagination, the researcher is able to set up an hypothesis which *could* explain by deductive reasoning the observed end results. Then the researcher goes about the testing of this unfounded hypothesis under other conditions. He will proceed with this method of attack modifying the hypothesis by the use of inductive thinking and imagination as he obtains new facts that show the need for modification. Both deductive and inductive reasoning are essential for creativity but inductive reasoning is the determining factor and certainly permits the greater opportunity for applied imagination and ingenuity.

The primary distinction between judicial thinking and creative thinking is that judicial thinking is almost devoid of inductive reasoning. Judgments are developed from the facts primarily by means of deductive thinking. The general principles or laws have been established and interpreted previously.

On the other hand, in creative thinking, facts serve merely as a starting point from which one reasons by inductive processes assisted by deductive reasoning to new principles and new and untried situations. This requires applied imagination and ingenuity particularly for the inductive processes.

Certainly the engineer entering industrial research should be well trained in inductive as well as deductive reasoning. However, the way our present day engineering curricula are presented, insufficient attention is devoted to the development of the student's ability to think inductively. On the other hand, excellent intensive training is given the student in deductive reasoning. One of the reasons for this may be that it is far easier to present a subject to students by deductive methods rather than by inductive processes. It takes considerably more time and planning on the part of the teacher to present the subject matter by induction.

In this connection, I was impressed with an article by Clarence H. Boeck in the October, 1953 issue of *The Science Teacher* entitled: "Try The *Inductive* Approach." Dr. Boeck describes one of his experiences at using the inductive method in teaching chemistry. I shall not take time here to relate Dr. Boeck's experience but I recommend the article highly to those engaged in teaching science or engineering subjects. We have given much attention to what to teach but I believe we should give more attention to how to teach.

A great deal of intensive training could be given the students in inductive reasoning in the present engineering curricula but this would require drastic changes in the methods of teaching. Furthermore, it might be well to give serious thought to the addition of courses designed specifically to develop the student's ability to think inductively. This might show up some interesting differences in the abilities of students. I am sure that all of you have been amazed at times at the poor showing of a graduate who had very high grades as a student. In some of those cases that have come to my attention, I have wondered if it might not be that the grades gave no reflection whatever of the student's ability to think inductively.

Recommendations

So I would recommend just as intensive training in inductive reasoning as in deductive reasoning to prepare the young engineer for industrial research. However, I would recommend this for all engineering graduates because the primary responsibility of engineering schools is first to train well balanced men and women. Such people will fit into research much

better than the unbalanced, narrowly trained graduates. The engineer of the future must be better informed in such fields as history, economics including business and finance, philosophy, psychology, government and politics. Technical and scientific skills will become merely prerequisites.

It is of great importance that the graduates of our engineering schools be trained broadly and that they be able to think skillfully both inductively and deductively. Also, concentrated effort should be directed toward developing the judgment of the student. He must be made to realize that this quality is undoubtedly the most valuable he can develop. It is far more valuable than brilliance.

The great successes of life do not go necessarily to the most brilliant, nor to the cleverest, or shrewdest, or the best educated. They go to men of soundest judgment. There is no quality so important for the executive as good judgment.

People who have the responsibility for selecting engineers for high positions are afraid of the poorly balanced, narrowly trained men. A man may be smart, sharp, shrewd, clever, a good scholar—even brilliant—but is he sound? Many over-estimate the value of education and brilliance. These are certainly no substitutes for sound judgment—no more so than is knowledge a substitute for wisdom. There is no substitute for soundness of judgment.

Therefore, it is urged that the engineering student not be trained specifically for research. Give him broad intensive training. Develop his sense of proportion. Teach him to think inductively as well as deductively. Give him training in the application and development of his imagination. Allow him the opportunity to develop his ingenuity.

In essence, I hope the engineering schools will turn out well balanced engineers who can practice successfully in any field if their aptitudes are compatible.

College Notes

An evening graduate course for those interested in digital computers and other systems operating with digital information is being given for the first time by **Stevens Institute of Technology.**

A series of evening courses in electrical engineering designed for men in industry who want to bring their knowledge of electronics and circuit theory up-to-date is being given by the **Columbia University** School of Engineering during the Winter Session. The courses are intended for students with B.S. in engineering or science. Completion of the six courses offered will make the students eligible for a graduate program leading to a Master of Science in electrical engineering.

University Extension of the **University of California at Los Angeles** will offer a ten-day engineering and management course from January 23 through February 2, 1956. Six hours of class per day plus luncheon and dinner meetings will cover both traditional and new areas in industrial engineering and management theory and practice.

Dr. G. Wesley Dunlap of General Electric has been appointed visiting professor at **Massachusetts Institute of Technology.** He is on a year's leave of absence from his position as manager of the Instrument and Nuclear Radiation Engineering Services Department.

Value of Research to the Institution*

By G. H. HICKOX

Program Director for Engineering Sciences, National Science Foundation

For the purpose of this paper, it may be assumed first that the institution referred to in the title is an educational institution. Most educational institutions have three principal objectives to fulfill: instruction, research, and public service. These three functions are interrelated, research being of value both to instruction and to public service. It may also have other values internal to the institution. There seems to be no doubt that a little research might improve the utilization of physical facilities and teacher abilities, but these aspects will not be dwelt upon, important as they may be.

A second assumption is that the value of research to an institution is the value that it may have to the institution's objectives of instruction and public service. Consider first the value of research to public service. Probably the commonest and best known application of research to public use is exemplified in the Agricultural Colleges of our Land Grant schools. The Agricultural Experiment Station associated with these colleges are continually at work improving crop yields, soil fertility, animal husbandry, poultry raising, dairy practices, farm economics, harvesting methods, marketing, and many other areas important to American agriculture. Our agricultural researchers have been notably successful in their efforts to improve the situation of the American farmer. They are teaching him better farm practices and are providing him with modern, efficient machinery which will lighten his work load.

Closely related to the work of the Agricultural Experiment stations is the parallel work conducted in Home Economics colleges and disseminated throughout the State by a group of home demonstration agents who work closely with the county agents. The work of these colleges and their representatives in their public service relationships is a striking example of the value of research to the public service function of the Land Grant school.

Another research activity which assumes importance in some areas is provided by colleges or departments of Business Administration. The University of Tennessee, for example, maintains within its College of Business Administration a Bureau of Business Research which is available to business and industry in this State as a public service. The Bureau publishes regular bulletins showing the status of business in Tennessee and discussing currently important matters such as taxation and legislation.

A Third Assumption

Returning from this brief digression, a third assumption may be stated: namely that we are concerned chiefly with instruction; and a final fourth assumption, that we are concerned with instruction of engineers. The value of research to instruction will require a little more discussion than the previous subjects because the results are not so immediately evident although this is not to say that they are none the less real.

Before discussing engineering education in detail, it may be well to stop for a moment and consider just what it is we are talking about. For present purposes,

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engineering may be defined as the *economical application of science and the materials and laws of nature to the satisfaction of human needs and desires.* A recitation of some of the human needs that are satisfied by engineering will illustrate the wide scope within which we operate. Engineering has provided us with our modern transportation by land, sea, and air, our marvelous communication system, our homes, offices, and factories, our enormous power supplies, and even our means of making war.

Need for Scientific Knowledge

And now consider that all of our recent progress has been based on new scientific knowledge, and that further advance must be based on scientific knowledge which is being discovered today or will be discovered in the future. Consider also that we in this country have no monopoly on the production of scientific knowledge or the ability to apply it. We must realize that if America is to maintain its leadership in the world today, we must develop to the full our scientific and technological resources. This requires the training of scientists for the production of new knowledge and of engineers for its intelligent application.

Prior to World War II, much of the basic scientific research was performed in Europe and we were largely importers of new knowledge. The European source was almost completely dried up during the war, and through that period and for some time thereafter, very little new knowledge was forthcoming. We were rapidly approaching the point where the satisfaction of human needs would be handicapped by a scarcity of basic scientific knowledge. It was in part to supply this deficiency that the National Science Foundation was established by the Federal Government for the support of basic research. Many industries and universities have likewise recognized this need and are encouraging basic scientific research. Only with the production of new knowledge will we be able to expand our technology to satisfy our ever increasing needs and desires.

The production of new knowledge alone, however, is not enough. It must find modes of application and these applications require engineers. Traditionally the scientist and the engineer have divergent viewpoints and each from his own vantage point looks down on the other. The engineer, concerned with application, considers the scientist a long-haired recluse who has no idea of practicality. The scientist, engaged in pure research, is as apt to think the engineer a hairy-eared dirt grubber. The divergence of views leads to divergence of action as well with the result that neither understands the other and there remains a wide gap between scientific discovery and its practical application. This gap, that exists between the pure scientist who pursues knowledge for its own sake and the engineer who applies it and adapts it to use, must be filled. It can be filled either by the scientist turned engineer or by the engineer who understands science. We are having difficulty today in training enough scientists to produce the basic knowledge that we need for our later use. It would be extremely unfortunate if the few people who are capable of extending the boundaries of our knowledge were diverted from this pursuit to the application of it in engineering ways. If the scientist departs from his profession to become an engineer, he ceases to be a scientist and this we cannot afford, for we badly need our research scientists to supply the store of knowledge which engineers may later apply. It seems important that we proceed by training the engineer in the understanding of science rather than by making scientists into engineers.

The Educational System

Let us now return to engineering education. We may think of our education as a two-phase system composed of a transmitter, or teacher, and a receiver, or student. Good education depends on the proper functioning of each of these two

phases. As educators, we must stimulate our teachers to the best performance of which they are capable and we must also motivate our students to exercise their will to know. Why are students in classes in our engineering colleges rather than in history, business administration, or mathematics? I like to think that they are in engineering because of the challenge offered to them by the production of new satisfactions for human needs and desires. I like to think that they are here not simply to learn how to do what their fathers and grandfathers have done before them but because they are challenged by a desire to push the frontier of service ever farther.

Since the function of our engineers is to apply the results of scientific learning to the satisfaction of human needs, it follows they must understand the sciences in order to be able to apply them intelligently. To promoting this understanding, our engineering colleges should devote themselves. This means that it will be necessary to teach more of the basic sciences in a scientific way, and we find in fact that engineering education today is in a state of transition from a program with emphasis on technical applications to a program which has much more emphasis on basic theory, on education in the sciences, and on training in research. If we are to teach in our engineering colleges only a knowledge of science and the techniques of its application, we may achieve a technical training, but we are not producing educated engineers. We must be training our students not only how to apply science but also in the understanding of science, and this must be done in the undergraduate curriculum. If the more specialized techniques of application must be taught, then the place for them is in the graduate school of such training may well lead to professional degrees.

Two Wills

We are told that human beings are provided with two wills: the will to know and the will to tell. We possess these in varying degrees but only through their exercise do we preserve, pass on, and add to our cultural and intellectual heritage. These wills should be cultivated. We should stimulate curiosity in our students so that their will to know may be increased and our knowledge thus be expanded. We should encourage them in their means of expression so that the will to tell may be satisfied and the knowledge gained by them may be passed on. To this end we should pay particular attention to the writing of essays and reports. Too often there is lack of cooperation between departments in our schools. The scientific departments pay little attention to grammar and composition, laying any defects in these directions at the door of the Department of English. The English Departments, likewise, are scornful of scientific knowledge. It is the responsibility of all departments to recognize that our culture has an essential unity and that the best interests of our students are not served by operating in an academic vacuum. It is our duty, if we are to maintain our place in the world, to develop our students to the limit of their abilities. Such development may result from contact with teachers who stimulate by example. Most of us can recall certain teachers who influenced us greatly by their mental alertness, by their intellectual curiosity, or by their professional attitude. The effects of the example set by them have undoubtedly lingered long after the details of their courses have faded.

Techniques of Research

The intelligent application of science requires training in the techniques of research. At the graduate level, research and instruction go hand in hand, but what about the undergraduate? What does research do for him? Formal research in an educational institution does a number of things for the undergraduate student even though he does not participate in it directly. First, teaching at the undergraduate level will tend to become dull

and routine and will certainly lag far behind current practice unless the teacher continues to grow and to develop. Such growth and development of teachers can only occur if they are aware of and practice the researcher's way of life. Research is a way of learning; a way of the mind; a continuous satisfying of the curiosity; a continual advance into the unknown. It is the way we have developed and advanced our culture. Students come to an Engineering College because they are challenged by the future. They wish to have a part in discovering it. This motivation should be encouraged and capitalized upon and it can only be done by teachers who are conscious of the challenge offered and who are themselves taking steps to meet it. The interests and the attitudes of our teachers are reflected in the training of our students. The institution with a positive attitude toward research, staffed with a faculty having an interest in and a sympathy for research, will stimulate students to a high level of achievement and creativeness that will not be reached if instruction is confined merely to the passing on of facts.

Atmosphere for Learning

Second, the atmosphere in which the student learns is favorably modified by research in the institution and course content itself is often improved if his teachers are actively engaged in research. New knowledge gained through research is not filed away as data in cabinets or reports on shelves. The new facts uncovered become a part of the curriculum and thus a direct and immediate benefit to the student. Teachers who have been engaged in classified, contract research—and this is not basic research, but application, not directly related to undergraduate instruction—have found that the work they have been doing in the application of science to the fulfillment of their contract obligations has made them better able to understand their own special fields. This is quite understandable because the application of science requires a knowledge of it and successful application requires an understanding of it. These teachers have found that the increased understanding of their own fields required by the application to special needs has enabled them to teach the basic science to their students with fuller meaning. This is one of the advantages of research—even of classified contract research—which is not generally recognized. It is, however, none the less real. As a matter of fact, it may even be true that research of this type is reflected in undergraduate instruction fully as quickly as research into the borders of knowledge which the undergraduate may not be fully prepared to understand.

Third, an institution which has underway a program of research finds many opportunities to utilize the services of undergraduate students for participation in the work. Such actual participation serves to stimulate the interest of the students, to maintain their motivation, and to train them in the techniques of research which should be a part of the educational process. These are some of the immediate and direct benefits of a formal research program.

Important Concept

Above and beyond these direct benefits, however, is a broader and more important concept. Research is the indispensable attribute of the engineer who will advance his profession or even keep up with it. In this sense all engineers must conduct research if they are to realize the potentialities of their chosen profession or to make their dreams come true.

Finally, and not least, is the concept of research as a way of life, an attitude of mind, a fulfillment of the human wills to know and to tell, the preservation, the extension, and the transmission of our cultural heritage. This is the way in which the university can fulfill its obligation to society.

The Value of Research to Graduate Instruction*

By WILLIAM G. POLLARD

Executive Director, Oak Ridge Institute of Nuclear Studies

At first sight the title of this paper seems almost trite. What can be said apart from the repetition of time-worn platitudes on such a subject? Is it not true that research lies at the very heart of the graduate program? What would a Ph.D. or even a master's degree be without a dissertation or thesis involving independent research? Is a graduate program thinkable without a strong central emphasis on the value of research in it? Such questions as these make the whole subject appear to be clear cut and simple. Yet apart from the traditional and theoretical values of research in graduate education, there are practical and empirical aspects which make the subject appear much less simple and clear cut.

To begin with there is the largely post-war phenomenon of industrial research institutes associated with universities and of the multitudinous government research contracts which have sprouted and multiplied in the science and engineering departments of our universities. In many cases these activities have come to command so much of the enthusiasm, interest, and energy of the faculty that teaching, even at the level of graduate instruction, seems to have become a secondary, even peripheral concern of the department. All too often a professor reluctantly and grudgingly interrupts his project research to meet a classroom schedule which he has come to regard as a necessary evil. The associate lack of enthusiasm for the educational enterprise as such is communicated to the students, and the result is not only a sharply decreased effectiveness of instruction, but often a loss of students to other fields. This whole situation may well be one of the major contributing causes for declining enrollments in science and engineering about which there is currently so much justified alarm.

Secondly, there is always the tendency, particularly in departments with large numbers of graduate students, for thesis research to approach mere hack work. Under the pressure for finding a considerable number of thesis assignments which are fairly sure-fire, unimaginative and often trivial problems are selected in which research is reduced to apparatus construction and data taking. Although such assignments do have some value for training in techniques, data analysis, and report writing, it is not surprising that the ever-growing pressure for more courses, which every curriculum experiences, leads in such cases to serious questioning of the value of research in graduate instruction. From the standpoint of the students, such research comes frequently to be regarded as simply one of the most heavily time-consuming and onerous of the obstacles placed between them and their degrees by an arbitrary administration.

Finally, there is the very serious problem in every technical field today of the enormous increase of the volume of knowledge required for competence in the field. Just a few decades ago the core of a graduate education in physics involved only classical mechanics, electromagnetic theory, and possibly relativity theory. Today all of this is still basic but there

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has been added to it as equally basic quantum mechanics, and now quantum field theory. For graduate work in chemistry there has been added to the whole structure of classical chemistry, the quantum theory of valence, atomic structure, and spectroscopy. The engineering fields are currently struggling with the evident necessity for basic training in nuclear physics and radiation on top of already too crowded curricula. More and more the question is being seriously raised as to whether the traditional dominant role of the research problem and thesis in graduate education can be justified in competition with such cogent and compelling subject matter demands.

It may perhaps be sufficiently clear from these considerations that our topic is by no means so simple and clear cut as it may at first have appeared to be. There are practical, if not theoretical, difficulties of a very real and certainly most stubborn character in contemporary graduate education in science and technology, which raise questions about the traditional values assigned to research. I wish it were possible for me to say something significant to you today by way of suggesting feasible paths out of these difficulties. Unfortunately I have neither the wisdom, nor any longer the immediate experience of day-to-day grappling with them, to attempt such a task. The more I hear discussions of these problems by those engaged directly in graduate education, the more I realize how exceedingly stubborn and complex they are, and the less am I inclined to launch brashly into the blueprinting of a solution.

Subtle Aspect

There is, however, one rather subtle aspect of this whole problem which seems to me both fundamental and crucial. This is what I like to think of as the "community" character of both scientific and technological professions. Here I have in mind that aspect of graduate education which is directed toward the full incorporation of the students into a professional community, as opposed to such other aspects as course content, mastery of facts and methods, or the development of facility in techniques and equipment. It is from this standpoint, it seems to me, that the value of research in graduate education can be most fruitfully discussed.

Those who are involved in the process of graduate education tend to become more and more preoccupied with the machinery. This is natural and indeed to a certain extent inevitable. When improvements are to be made in the process, one naturally looks for specific steps which can be taken. But such steps always consist of modifications in existing courses, new courses, new laboratory experiments, special student projects, and the like. But important as all of these formal aspects of the graduate program unquestionably are, they nevertheless do not touch the real heart of the problem.

The difficulty is that the heart of the matter is so subtle. For basically what we are trying to do in graduate education is to turn out competent members of our own professions. That is we are not so much trying to teach physics or chemistry or engineering, as we are trying to develop physicists, chemists, and engineers. These two objectives are, however, quite distinct from each other. Physics and chemistry overlap extensively in content and subject matter; so much so indeed that it has become essentially impossible to frame adequate definitions for either of them in terms of bounded subject matter provinces. There is, however, no difficulty when it comes to telling a physicist from a chemist. They are quite clearly members of two different communities of inquiry with different ways of approaching the same problem and different criteria for determining what is significant and important. Indeed there have been those who, despairing of the possibility of finding an adequate definition of physics in terms of classes of phenomena, subject matter categories, or methodology, have sug-

gested defining the subject as consisting simply of everything done by physicists.

Such a definition of physics, chemistry, electrical engineering or any other scientific or technical field is not as trivial or tautological as it may at first sight appear. For each of these subjects has come into existence historically because of the formation of a dedicated community of men sharing a common approach to the investigation of nature. None of these communities of inquiry could foresee what areas of nature this approach would ultimately lead them into, or what content their subject would acquire as a result of their investigations. The plain fact of the matter is that the content of chemistry today is what it is, not because of any inherent segregation of natural phenomena along the lines delineated by the contents of a modern textbook of chemistry, but purely and simply because that particular body of information represents the aggregate fruit of the labors of chemists over the years. Each of our subject matter fields exists because of the creative activity of a community of investigators with a common bond between them. Every such community has tremendous creative power of itself. Its members learn from each other and teach each other. Only within the community can the achievements of each member be fully appreciated and only within the community can the rigid critical discipline necessary for real achievement be applied to each member in a spirit in which it is gladly accepted.

If we look upon our several scientific and technical fields in this light, then I think you will all agree that the really basic objective of graduate education is not primarily the acquisition by the student of a certain predetermined level of technical information and professional competence, but rather his full incorporation into the professional community. The basic objective of a faculty of chemical engineering is to turn out men who both feel themselves to be chemical engineers and are accepted as such by the profession at large. Certainly the achievement of this objective depends in a critical way on an adequate mastery of a body of subject matter, knowledge of and facility in both intellectual and manual techniques, a balanced sensitivity to technical and economic limitations and possibilities, and many similar competences. But although all of this is essential, it does not of itself add up to a real chemical engineer. There is a clear overplus required which I think we all recognize, but which is very difficult to define or pin down.

Confrontation with the Unknown Tests a Man

It is just here that the importance of research enters the picture. For it is in the carrying out of significant research more than in any other activity that the subtleties we have been describing are transmitted from professor to students. In any professional field it is the confrontation with the unknown that really tests a man. That which really makes a scientist or an engineer what he is reveals itself when he comes up against an important problem whose outcome is unknown and whose solution is not obvious. In such a situation all the undefined bases of confidence, the sureness of approach, the characteristic ways of going about things, and the peculiar disciplines that make a physicist or a chemical engineer what he is show themselves. The student, confronted with the unknown in this manner in his own research, derives more than he will ever thereafter be able to explain from the experience of having his major professor join with him at critical phases of his investigation. In such situations the full implications of the nature of the profession are directly experienced by professor and student together. This, however, is the only manner in which they can be acquired, for there is no way in which they can either be taught or learned.

From this standpoint we can see why artificial problems or hack-work research

will not do. It is only in real, living situations that these qualities emerge. It is necessary that the problem be considered significant and important by both the professor and the student, as well as by the professional community at large. It is also necessary that the problem really challenge the professor as well as the student. Mere data taking, report writing, or routine or made-up problem solving are powerless to evoke these values. The adventure of research with all its alternations of joy and despair, of excitement and drudgery, must really be present and fully shared by professor and student together if the objective is to be obtained.

During the last several years I have been involved on several occasions in discussions of the problem of what the engineering schools should be doing about the new field of nuclear engineering. I feel sure that all of you in this Society have wrestled with this problem extensively yourselves. For my part the aspect of it which has emerged increasingly clearly in my own thinking is the effect which the absence of a sense of professional community has upon this problem. Most universities have been able to introduce quite adequate new courses and additions to existing courses into their curricula to meet the needs of engineers planning to go into nuclear work. By now there are also reasonably adequate texts and reference materials available for such courses. Short of an operating nuclear reactor, it is even possible to provide essentially all of the necessary laboratory work for instruction in this field. But in spite of the adequacy of such instruction, it does not result either in attracting students to the field of nuclear engineering or of producing men who are distinctively nuclear engineers.

One of the committees which the Oak Ridge Institute of Nuclear Studies called together two years ago to study this problem expressed the matter this way:

> The most important problem is that there does not exist within the universities a nuclear energy tradition adequate to meet the demands which will be made of nuclear engineering education at the highest level. This inadequacy comes primarily from the fact that almost all the highly competent or authoritatively informed people in the field are still in the industrial or government areas; few have so far found their way into the educational framework.

Crucial Element

At the heart of all professional education, particularly at the graduate level, lies this recognition of the existence of a living community of persons with a special professional competence. Within the university where the community enlarges and extends itself, the process by which it does so is not so much one of teaching and instruction as it is one of contagion and reproduction. This it seems to me becomes very clear in an entirely new field such as nuclear engineering where one can see the effect of providing only teaching and instruction in the absence of persons who consciously and recognizably represent the new professional community as the primary center of their professional life and challenge.

Once this idea is recognized as a crucial element in the whole educational process, it seems to me that the role of research in graduate education becomes evident. From this vantage point, research can no longer be considered merely as a teaching device for the learning of specialized techniques, the development of habits of precision, or the encouragement of independence. One comes instead to see graduate student research in the light of the occasion it provides for the sharing of a unique kind of experience by professor and student together in a manner which is peculiarly reserved to their special profession. Since such occasions play such an indispensable role in the process by which our several professional communities extend and reproduce themselves, it is difficult to see how we can really make a student one of us without making his research project a central feature of this graduate education.

The Fight for Ethics in Engineering*

By JOHN R. SNELL

Professor and Head, Department of Civil Engineering, Michigan State University

A young man who clerked after school asked his father one day to explain to him the meaning of ethics in the field of business. His father replied, "If a customer should unknowingly pay me $10 too much, ethics is whether or not I tell my partner."

I consider it an honor and a challenge to outline something of the fight going on to raise the ethical standards in the Engineering Profession. I hope to enlist your enthusiastic support in this battle. Our greatest opposition is still a lethargy on the part of the engineers themselves. This is largely a problem of education and one for which we should feel compelled to accept full responsibility.

Discussion might best be confined to the following three questions:

1. How serious a problem is Ethics for the Engineering Profession?
2. What are and what should the engineering societies do about the problem?
3. What are and what should the educators do about the problem?

There are others far more capable of discussing these important subjects but probably none would be as frankly outspoken about the problem. My suggestion to each of you is that you take the responsibility upon yourself to read all the articles written on engineering ethics in the last two or three years and do some independent research and hard thinking on the subject. This study may help you get a burning conviction of the bigness of the job to be done and help you feel your part in accomplishing it.

* Presented at the Annual Meeting of ASEE, Civil Engineering Division, Penn State University, June 23, 1955.

Serious Problem

First: How serious a problem is ethics in the Engineering Profession? It is far more serious than most engineers realize or would be willing to admit. Four important basic ethical problems face the profession. The first two show lack of integrity or actual dishonest practice; the last two involve the ignoring of accepted ethical standards of the profession. They may be stated as follows (1):

1. Giving "kickbacks," "commissions," "finder fees," "payment for influence" to assist in obtaining engineering work;
2. Accepting commissions or engineering aid directly or indirectly from contractors, equipment manufacturers or other parties;
3. Reducing fees below minimum accepted standards or competing on the basis of price;
4. Undercutting the professional reputation of another engineer or attempting to supplant an engineer where steps have been taken to employ him.

The vicious malpractice of giving kickbacks or accepting commissions from manufacturers and others was widespread four years ago in many of the larger cities on the Eastern seaboard and the midwest, and I understand is little improved today. The malpractice of reduction of fees is to some degree present almost everywhere. This, of course, leads to poor engineering, uneconomical designs and a low professional standing. The malpractice of "bidding" has received some attention and publicity in the last year yet it still continues (2) (3). Undercutting and supplanting fellow engi-

neers is privately admitted in even some of the most respected engineering firms when competition gets tough.

Everyone gives lip service to ethics but what actually takes place is something else again. This was evidenced also in October, 1954, in an open meeting held in Cincinnati by the Ethics and Practices Committee of the Engineering Council for Professional Development (5).

Four years ago a story of my own experience with malpractice in the profession was turned down by a half-dozen national engineering magazines because in their editors' minds it was too hot an issue for publication. The JOURNAL OF ENGINEERING EDUCATION published it in uncensored form in May, 1953 (5). The response to the printed article by the engineering educators was encouraging. One insisted it should not remain buried in the JOURNAL, and 400 reprints were sent to the state and national offices of various engineering, architectural and contractors organizations.

These stirred up interest where it was needed and over 1500 additional reprints were ordered. A supply of the reprint is available for the asking.

How will the continuation of these malpractices affect the Engineering Profession? The respect and high professional esteem given us by the public is already being severely shaken in some areas and may be undermined completely if it long continues. High ethical standards are a firm prerequisite to any profession, especially the engineering profession (6). The public will not stand for an egg that is nearly fresh, a boat that floats most of the time, or a parachute that almost opens.

Second: What are and what should the engineering societies do about the problem? Perhaps we can better understand the problem if we first compare ourselves with our friends in the medical and legal professions. The doctors through their American Medical Association and the lawyers through their American Bar Association may severely reprimand one of their members, or if the malpractice is serious enough, may take steps to have him disqualified from practice (7) (8) (9). Doctors and lawyers alike have been very active in controlling any violations of ethics in their professions. Especially has this been true on the west coast where their problems have been serious.

The engineers, in contrast, have over eighty different societies. Despite the fact that a standard Canon of Ethics was adopted by a majority of the societies in 1947, it has had little or no effect in improving the situation. The greatest punishment which one of these engineering societies can administer for malpractice is expulsion from that particular society 1947, it had little or no effect in improving the situation. The greatest punishment which one of these engineering societies can administer for malpractice is expulsion from that particular society and even here unethical engineers are partially protected by the ethical obligation of all engineers to refrain from "harming" another member of the profession. Also, most cases of unethical practice in engineering are difficult, if not impossible, to prove; so why bother to prefer charges when the chances of proving them are slight? In the last analysis, expulsion from an engineering society in no way affects the engineer's right to practice. Unethical men are often callous to this almost meaningless type of reprimand and become all the more determined to continue their profitable malpractice.

No Central Watchdog Agency

Despite this serious handicap for the engineering profession, of no central watchdog agency such as is available to the doctors and the lawyers, some small progress is being made to improve ethical standards. The twenty or more articles in our technical journals on ethics in the last two years are evidence that serious thinking is going on. Ethics and practice committees of many of the major

engineering societies have been reactivated and are again beginning to study the problems confronting them for fresh answers. Increased reprimands by the ASCE and NSPE this past year for bidding (3) (10) is a good indication that the societies mean business.

As a member of the Ethics and Practice Committee for the Michigan Society of Professional Engineers, I have seen some serious study given to the state and national problems. For example, a suggested program on ethics and practice has been prepared for national usage to educate the following ten areas on ethical standards and practices of engineers:

1) Municipal officials
2) Equipment manufacturers
3) Industrial management
4) Engineering professors and students
5) Telephone companies
6) Organized labor
7) Engineers
8) Architects
9) Surveyors
10) Contractors

Each area has different problems and a continued educational program is recommended through the discussion of these problems by qualified men in appropriate periodicals.

Other programs under way include proper classified telephone listings of professional engineers, employment of only registered men in responsible public engineering positions, investigation of such unethical practices as are reported to have occurred, and elimination of competitive bidding for professional services.

A most important and difficult task yet lies ahead. So far the problem has been generally avoided despite the fact that in its solution lies the key to any major upgrading of ethical practice in the engineering profession. Basically it is a problem of setting up a single workable mechanism for the profession to effectively deal with unethical engineers, just as doctors and lawyers are able to reprimand unethical members of their professions. Our present systems vary from society to society but all have the common fault of being unworkable and ineffective. The control of unscrupulous men in the engineering profession by present methods is about as effective as the Girl Scouts controlling crime in Chicago. Several of the major engineering societies should take responsibility to formulate a workable effective plan and sell it to the other societies. This cannot wait 10 or 20 years to happen without endangering the professional standing and reputation of engineering in general. This conviction is a growing one, as is indicated by Mr. H. A. Wagner, consulting engineer and chairman of the State Boards of Examiners (7). The newly formed Board of Ethical Review (11) of the National Society of Professional Engineers may be a first step in the right direction, but let us not rest until the job is done completely and effectively and we have a watchdog which is a watchdog.

An interesting report on engineering ethics in England and on the continent by Fritz D. Hirschfeld (12) indicates that ethics are taken much more seriously there than in this country. In Sweden, for example, a promissory note for $2600 is held by their engineering associations as a guarantee against malpractice.

Growing Problem

Another serious and growing problem should be mentioned before passing on to the third and final phase of this discussion on ethics. The unions have made alarming inroads on the lower pay brackets of our "engineers-in-training" and, in fact, on our professional engineers themselves. This problem has been ably discussed by both Dean Dougherty, Dean Freund and others (13) (14). Essentially the problem is higher wages and recognition of professional status of these men by their employers. Both industrial management and the young engineer alike need to be educated for the best solution

of this problem. For some consulting firms the problem may have roots in "fee cutting." In any event no one really wants the unions running any part of the engineering profession.

Third: What are and what should the educators do about the problem? We in engineering education are concerned as to what we are doing and what we should be doing to improve ethical standards and practice in the profession. The reports given by Dean C. J. Freund, Chairman of our Society's Ethics and Practice committee are revealing (15) (16). Indications are that many educational institutions are doing virtually nothing to give their engineering students an understanding of ethics in their profession and the vast majority of schools are doing far too little. Only a handful of the institutions appear to be doing a first class job. The problem appears to be two-fold:

1) Our crowded engineering curriculum makes us feel that time cannot be spared for a formal course in ethics.

2) No suitable text or collection of material is available and also many educators feel that ethics cannot be effectively taught in a formal course.

To a degree all this is true, yet we cannot overlook a serious problem because of a lack of time or a lack of tools. Materials presently being solicited by the Ethics and Practices Committee of the ASEE may well form the basis of an effective course (16). The January, 1955 issue of the *Annals of The American Academy of Political and Social Science* (7) would be a very valuable reference for students and teachers alike. Time can always be gained from some other area—either technical or non-technical. There is no use making a good technical engineer if he can't be honest! Further conviction on the need for teaching ethics and some helpful suggestions are given by both M. D. Cooper (17) and N. W. Dougherty (18) in recent articles. Mr. Cooper suggests that if a full course cannot be given on ethics a substantial part of a general course on Engineering Practice should be devoted to the subject or perhaps a series of seminars should be held.

Tau Beta Pi should be congratulated for its two recent forward steps to promote high ethical standards (19). First, every electee was encouraged in 1955 to write an essay before his initiation on some topic concerning engineering ethics. Second, distribution of a brochure on ethics is made to each electee.

Students should be encouraged to read and to think independently in the field of ethics. Writing for the Daniel W. Mead essay contest with $50.00 and $100.00 prizes should be encouraged (20). Student society meetings, both technical and honorary, provide an excellent chance for growth in these moral standards. Special lectures and speakers on ethics can help to mold students' minds and formulate their standards of personal and professional conduct.

Honor System Valuable Tool

My own experience indicates that the student honor system is a very valuable tool in teaching moral values and building character in young men. Every engineering school should aim for a student-run honor system and their staff should each take a personal responsibility to know the students well enough to make certain that it is functioning one-hundred percent (21).

One final point and probably the most important one. Engineering ethics cannot be taught in the same sense that math or structures are taught. A student's grade of "A" in his Ethics class gives no assurance of his honesty, fair play or moral guide posts he has chosen to govern his way of life. These qualities have been fairly well formulated into what we call the student's character long before we as college teachers come in contact with him. The greatest influences on these students' characters are their homes, friends, schools and churches. Some influences may have

been uplifting, some degrading. What the engineering faculty says and does both in and out of the classroom have a very important part in the building of character of our young engineers. The building of a high moral climate is every teacher's job. Let us remember that the roots of all sound ethical standards are moral and spiritual.

Probably the most scientific and outstanding experiment and experience comes to us in the Kentucky Program of Moral and Spiritual Values in Education launched in 1946 (22) (23). This has been a unique cooperative program of the Kentucky State Department of Education with nine colleges and universities and two foundations. Remarkable success has been reported in teaching students moral and spiritual values not through special classes on such subjects, but through a carefully planned program of bringing out and emphasizing these values both in the existing formal curriculum and in extra-curricular activities. The success of the Kentucky program in these few years appears to many thoughtful educators as a turning point in education. It certainly would have an important bearing on the world ideological fight for men's minds! It can be our best and only certain way of integrating integrity with engineering technology. Finally, technology without integrity is like a ship without a rudder. If we are to continue to build ships, let us do the whole job and build the rudders as well.

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Midwinter Meeting of the Engineering Drawing Division

The Midwinter Meeting of the Engineering Drawing Division will be held from Thursday, January 26, through Saturday, January 28, at the Illinois Institute of Technology, Chicago. Registration will be conducted Thursday afternoon and Friday morning.

The General Session Friday morning will feature papers on *Technical Drawing for Science Majors* by E. G. Paré, *Design Consideration in Engineering Drawing* by H. C. Messinides, and *Relation Between Engineering Drawing and Machine Design* by L. M. Sahag.

Papers featured at the General Session Saturday morning will be *Should Colleges Teach Drafting Techniques?* by J. Gerardi, *Simplified Drafting* by J. H. Bergen, and *Introductory Nomography* by A. S. Levens.

Other activities will include a luncheon, luncheon and business meeting, banquet and miniature opera presentation, Open House at IIT's Technical Drawing Department, tour of the *Chicago Tribune* plant, and optional field trips to Chicago landmarks.

Enrollment and Incomes in Civil Engineering can be Increased*

By HARRY RUBEY

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Civil engineering has dropped to third place in enrollment and incomes. What can we educators do about it?

This paper attempts to look forward from fifty years of experience and to resolve the paradox of enrollment and income falling relatively while more graduates at higher incomes are needed for the technical and management staffs of American industry, especially for its largest industry, construction. The paper iterates briefly and brings up to date a paper and bibliography on a similar topic presented a year ago and published in condensed form in the *Civil Engineering Bulletin* of ASEE for March 1955. It should be useful in applying the findings of the ASEE Committee on Evaluation.

The Crisis

We, at the height, are ready to decline.
There is a tide in the affairs of men,
Which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.
On such a full sea are we now afloat,
And we must take the current when it serves
Or lose our ventures.

From Shakespeare's *Julius Caesar*

A critical shortage of engineers threatens national welfare. Secretary of the Air Force Quarles has recently written that this shortage of engineering and science graduates is a major peril to the United States, in contrast to the much greater number educated in these fields in Russia. Lt. Gen. Groves (retired), atomic expert, questions "How long can we expect to survive if our present annual production of engineers is only 20,000 and not increasing, while Russia's is 54,000 and constantly increasing?" We must note further that Russia also greatly surpasses us in training sub-professionals and in emphasizing mathematics and science at both higher and lower levels. Both Churchill and Eisenhower indicate that our present technical superiority may be short-lived.

As an example of great importance to civil engineering, the national Associated General Contractors of America, the national Highway Research Board, and many others warn that a shortage of civil engineers threatens construction and this in turn menaces all industry and national defense.

Construction and Education Are Essential for Full Employment

Most business commentators credit construction as a bulwark of present prosperity. Furthermore, prosperity for the future is even more dependent on construction and education. Construction will provide immediate jobs, and education will keep part of the labor surplus in school. For the more distant future, they together will provide the research, plant, equipment and personnel housing, automation, technical and management personnel, know-how, and jobs needed to absorb the two million new workers that

* Presented at the Annual Meeting of ASEE, Civil Engineering Division, Penn State University, June 23, 1955.

will be added each year to our present working force of sixty-five million persons. Construction needs more civil engineers; then it will provide more new industrial facilities that will employ more workers. Consumer and war spending does not create new plants although it does create a demand for them.

This constantly increasing supply of jobs is essential for increased living standards, for strengthened national defense, for winning political elections, and for the very life of a successful democracy. We are committed to it politically. No party can win an election without full employment. The alternative to a large construction program is a change of political administrations, unbalanced budgets, increased debt, inflation, and the ruinous effects of unsound money especially on white collar, old age, and low income groups. Construction can be largely self-liquidating and will support much education, both directly and indirectly.

Construction

For several years expenditure for construction, replacement, and maintenance of our industrial and governmental plants has exceeded $50 billion annually, thus becoming America's largest industry. The 1954 expenditures of $52 billion are increasing to over $56 billion in 1955 and should continue at rising levels. The overall construction program will comprise 15% of the total national production and will employ nearly 10 million workers. The highway program alone may spend $100 billion over the next 10 years.

Investigation by the national Associated General Contractors has indicated that adequate material, labor, and equipment will be forthcoming, but that the bottleneck in construction is the increasing shortage of construction engineers. The national Highway Research Board estimates that most of a year's entire U. S. output of civil engineering graduates may be needed soon for highways alone, instead of the few per cent annually entering that field.

High School Preparation

So that their students may be prepared for engineering, high schools must emphasize mathematics and science, especially mathematics, since such studies in high schools have dropped to an all-time low. Of a recent rural high school group of 250 boys and girls, a very satisfactory 36 per cent, all men, were interested in engineering, but only 5 per cent had the required 3 units of mathematics, 7 per cent had 2 units, and the balance 1 unit or less. This fatal obstacle must be overcome. More high school graduates of both sexes must be attracted to the large and well-paid fields of construction and management.

Civil Engineering Education

The engineering colleges must double their output of civil engineering graduates, of whom about a third enter the armed forces and another third accept minor management positions. Corresponding attention must be given to graduate study and research in the construction field. Such an educational program will be designed to give better, quicker, and less expensive construction; to reverse the increasing construction costs that now are a burden on every business and every individual; and to facilitate national defense.

There now exists the greatest potential demand ever known for civil engineers. Civil engineering technology is neither new nor spectacular, is not advancing as rapidly as that of other engineering, and cannot compete on these bases. Its lack of appeal to young men and women must be corrected. Considering all departments of engineering, civil now suffers slightly lower median incomes, due largely to low governmental salaries. By fortunate contrast, contracting and professional management pay the highest. Remedial action is mandatory. How little is, or can be, done by engineering societies toward increased incomes is explained in an editorial in *Engineering News-Record* for March 17, 1955.

Construction and "Professional" Management

How can we regain our lost prestige? Minor alleviation will not revive a declining phase of education, as witness the dead languages. We must maintain our proved and established disciplines but realize today's need for engineered construction and for professional management, then realistically prepare more students to meet modern critical industrial and defense demands while assuring increased incomes for them. The actual curricular change needed is slight and is far within the 10 per cent allowed by the ASEE Committee on Evaluation. Massachusetts Institute of Technology already has a major option in Construction and Management. We at the University of Missouri now use only six credits or four per cent of the curriculum for Construction and Professional Management, and other engineering colleges have similar programs. It is not advocated that descriptive details of construction and management be taught in college nor is it contended that the four-year graduate entering construction and management is fully educated. He, like the researcher or designer, must continue to learn although he will undertake graduate study less often.

However, as anything we want students to consider seriously, the importance of construction and professional management must be impressed upon them in many ways, although not glamourized. For example, they should know that already the 1950 census classifies half of professional civil engineers in construction, that management is now a profession requiring an educated professional viewpoint which is easily included in engineering curricula, that getting along with people is essential for both construction and management, and that even the technical engineer must know and conform to the aims of construction and management. Construction and management situations should be emphasized more in most of our courses. In line with modern trends and developments, we should publicize such terms as *engineer-contractor, engineered construction, construction management,* and *professional management.*

Construction (including suppliers of materials, equipment, and the like) provides mainly management openings. In addition, there are excellent positions for our men in the professional management of government such as in city managership and in highways; and in industry other than construction such as the railway, aircraft, oil, steel, chemical, and public utility fields. Fortunately, the civil engineer who is qualified in construction management can either remain in construction profitably or change over to upper level industrial management.

Because of obsolescence, new products, bombing hazards, decentralization, and the like, the construction and expansion program today is often as important to an organization as its operations. Thus former engineer-managers of construction now are becoming even more necessary and valuable as top professional managers for industry than in the past, and this has always been the civil engineer's main approach to top management.

Many of our graduates will find satisfying careers intermediately between management and technology as staff officers, consulting engineers, marketing specialists, financial advisers, managers for associations, and the like.

The Rise and Fall of Engineers as Managers

Around the turn of the century, managers were strong entrepreneurs and lucky gamblers (rarely engineers) who built their own businesses, and often lost them. The few larger corporations were often in receiverships.

Then followed a period of larger corporations managed mainly by lawyers, marketing men, financiers, and engineers who seldom had sought management positions; more often they were impressed into management. Failures still predominated the scene.

Since the great depression the need has become recognized for professional managers (most frequently engineers), not those rugged individualists of the early period nor the capable specialists of the middle period, but men trained from the beginning to become conservative professional managers (almost trustees) for unbelievably large and stable organizations where failure must be prevented. They are skilled in government, tax law, mergers, finance, public relations, and human relations; with their eye on management at intermediate and high levels, including board policy determination and above management details such as are usually taught in colleges. This group must start early, for example in college, to partly direct their attention toward professional management rather than exclusively toward technical specialization and science.

Civil engineers can better be pointed in this direction while in college than can other kinds of engineers who are becoming increasingly swamped under specializations in science, technology, and gadgets. Art, rather than science, characterizes both civil engineering and management. Even before this trend toward science the larger corporations favored civil engineers as managers. For example, half of the presidents of our larger railroads were civil engineers, while no other engineers occupied presidencies even though there were nearly as many of them on railroads as there were of civil engineers. And civil engineer executives predominated in the growing steel, oil, and other large industries. Consulting engineer-management firms frequently were staffed with a considerable proportion of civil engineers.

In November, 1952, a study in *Fortune* magazine showed nearly 45% of America's top industrial management to have engineering backgrounds. But it also showed that this percentage was greatly decreased (to 28%) for those under 50 years of age; in other words, that the proportion of engineers in top management had passed the peak and that younger engineers already were losing out to non-engineers (often to graduates in business administration) who more aggressively prepared and sold themselves for management.

Now civil engineers are losing their hardwon leadership and new examples of missing their management opportunities occur constantly. For almost the first time in history, a baggage master instead of a civil engineer has been made president of the Pennsylvania Railroad; a board chairman and civil engineer of Standard Oil of New Jersey was succeeded by a geologist; civil engineer president of A. T. & T. was succeeded by an electrical engineer; a cost-accountant has become board chairman of Ford Motors although in the past civil engineers like the late L. F. Loree, not accountants, mounted to top management through cost controls; a lawyer-financier has succeeded a civil engineer as board chairman of U. S. Steel; and a civil engineer president of the great Canadian Pacific Railway has been succeeded by a mechanical engineer with some interest in management.

There are those who will say that we should train good engineers and some will become managers, but nowadays the odds are against them and the possibility in this direction is rapidly diminishing. Civil engineers in the past were drafted into management, sometimes unwillingly, and they seldom prepared for or sought it. But conditions have changed. If we educators do not point out this management opportunity and give introductory study leading to management, our few graduates will largely remain technicians or modestly paid professional engineers and they will not be given management responsibilities and training by their employers.

Fortunately civil engineers now are needed to manage construction and can rise again in management by stressing education for construction and professional management. By the same process, some will develop the art of "how to be happy, though managed."

A Program

The present low ebb in civil engineering education has been developing over the years and will not remedy itself without strenuous effort on our part. Let us retain our established and proven disciplines but point them a little more toward construction and professional management, leaving additional basic science and specialization for graduate study. The holder of a bachelor's degree only seldom will become an outstanding professional designer, researcher, or educator and he should not be misled into thinking that he will.

As our management-trained civils take over more management positions that were being filled by others, those civil engineers remaining in design, development, research, and teaching will enroll for more graduate study, will become truly professional, and will be better paid. Our enrollment and prestige will increase; our graduates will think better of us; and from influential management positions they will more actively support us and our departments financially, by sending us students and employing them, and in other ways.

The national Associated General Contractors last summer established an Educational Committee that is prepared to increase actively its present cooperation with us. Chairman D. W. Winkelman of that Committee, also member of the American Society of Civil Engineers and president of the D. W. Winkelman Company which has just completed part of the Ohio turnpike, is author of an important article entitled "Construction Management Needs the Civil Engineer" in *Civil Engineering* for February 1955 in which he states, ". . . My purpose here is to stress what I believe is the equal necessity for thoroughly competent men to engage in the management of construction firms which actually build those facilities that are vital to the progress of the country. . . . Management needs the civil engineer with construction experience and managerial and executive ability."

Conclusion

In conclusion may I plead that civil engineering educators collaborate in a comprehensive and inter-related five-fold campaign before it is too late, including:

1. More mathematics in high schools, starting in junior high and involving close cooperation with high schools.
2. More effective solicitation of high school students, assisted by the Associated General Contractors, highway departments, and industry.
3. At least one course at the senior-graduate level in *Construction* (management, not construction details) and one course in *The Engineer's Relation to Professional Management* (principles, not details), perhaps including introductions to law and engineering economy.
4. Emphasis on these areas in our classes and public relations.
5. Sufficient research, graduate study, and public relations to assure getting our share of the college student body.

For want of a nail the shoe was lost,
For the want a of shoe the horse was lost,
For the want of a horse the rider was lost,
For the want of a rider the battle was lost,
For the want of a battle the kingdom was lost,
And all for want of a horseshoe-nail.

From Benjamin Franklin's *Poor Richard*

For the want of a realistic shift in emphasis, shall civil engineering accept a permanent third place in engineering? All five points of the campaign must be adopted together; they will not be effective separately.

Designing the Educational Program*

By G. A. HAWKINS

Dean of Engineering, Purdue University

During the past several years considerable confusion and many differences in opinion have resulted from discussions dealing with the remodeling of mechanical engineering curricula. The problem is complicated by those who are advocating more solid state or modern physics, more industrial management, and more of this and that. As a result some of us are redesigning programs of study simply by reshuffling courses, adding one or two and removing others in a manner which is not based on sound engineering analysis and synthesis.

My plea is to design the educational program in the same way that we would design any complex engineering system. First let us define the problem, establish the fundamental elements, design the program, and develop courses to accomplish the objectives.

In order to present my thoughts, I wish to define engineering in the following manner:

> Engineering encompasses the application of various principles and concepts of the physical and life sciences and background knowledge (the basis of the art of engineering) to the study, creation, and design of systems composed of structures, energy converters, circuits, processes, or combinations of these elements; and the analysis, synthesis, and prediction of their behavior under specified working conditions in terms of men, materials, cost, and time.

* Presented at the Mechanical Engineering Division Dinner, Annual Meeting of ASEE, University of Illinois, June 16, 1954.

I. *Characteristics of Professional Engineering*

Having established this concept of engineering, it seems desirable to consider briefly the characteristics of professional engineering. For this discussion, I would like to utilize information furnished me during personal conferences with Dean A. A. Potter, Dean L. M. K. Boelter, Dean C. S. Hollister, and many practicing engineers. A composite opinion indicates that some of the characteristic requirements and situations which confront professional engineers are:

1. Professional engineers are assigned specific tasks during the course of their work. This is not always the case with the scientists, for they are often free to select the problems which most interest them.

2. Professional engineers are always required to meet deadlines. They must reach a decision during a specified time interval. In general, time does not play so vital a part in the work of the scientist.

3. Professional engineers are almost always obliged to work closely with other people who have not been trained as engineers. Due to the complex nature of their problems and the many social factors involved, engineers often work as members of a team. For example, the design of a dam requires, in addition to the services of the engineers, assistance from geologists, economists, meteorologists, and many others. The scientist on the other hand often works alone or mainly with other scientists.

4. Professional engineers must devote their attention to problems which they

know will affect the lives of men in the future, while the technicians deal mainly with the problems of the day. The early civil engineers who laid out the railroads affected the lives of men for generations; since, in the design of the railroads, they indirectly established the locations for some of the great cities of today.

5. Like other professional men, the engineers must accept the responsibility of lifelong learning in order to keep pace with technical and social advances in their area of interest.

6. Professional engineers also must develop a keen sense of values and standards. Appreciation of human, moral, social, aesthetic, economic, professional, and of many other values is a necessary part of the engineer's make-up.

These are only six of the main factors which characterize and in some respects distinguish the professional engineers and their work; they should be kept in mind, along with the definition of engineering, during the remainder of this discussion.

II. *Other Functions Performed by Engineers*

There is no doubt that the education received by engineering students prepares them to perform with significant success many functions other than design—such as management, sales, operations, and maintenance. A great many engineering graduates have distinguished themselves in the management of industries, and many have risen to high executive positions.

The feeling has grown, especially among this group, that the subject matter of instruction should be changed to contain more knowledge of the actual procedures of management—even of top management—of finance, marketing, inventory control, etc. This influential opinion has had the effect in some instances of diluting the engineering programs with courses not directed toward meeting the main objectives of engineering as set forth above. The question then naturally arises: What percentage of graduating engineers actually pursue engineering work?

It is most difficult to acquire data relative to the classification of the work of engineers in industry and other organizations. As a result of discussions with many engineering educators and industrial people, it appears to me reasonable to assume that the graduates of engineering programs who pursue engineering as a career are distributed in the following manner:

Designation of Engineers	Percentage
1. *The Engineering-Scientist* These engineers are creative and discover new facts about engineering systems. This category also includes many engineering teachers.	5 to 10
2. *The Creative-Design Engineer* These are the creative individuals who actually design new engineering systems and put newly discovered principles into use.	10 to 20
3. *The Functional Engineer* These engineers employ orthodox methods and established principles in the design of conventional details of manufacturing plants and public utilities and they build, operate, and maintain these plants and their equipment.	40 to 50
4. *The Engineer-Technician* Engineers in this group devote their attention to the more routine tasks such as drafting, testing, inspection, record analysis, chemical and metallurgical analysis, etc.	10 to 20
5. *Engineers in Non-Engineering Work*	5 to 10
6. *Executive and Administrators* A large number of engineers in each of the above categories find themselves 10 years after graduation in executive, administrative, or ownership posts in industry, government, and utilities.	

All of these engineers are of vital importance in our modern society since each has his particular task to perform. The results of their labors account in large measure for the great industrial growth of America.

Let us assume that many of the graduating engineers elect functions such as management and others which are not strictly engineering according to my definition. It then becomes apparent that for every 100 engineering graduates only a few will be in the engineer-scientist and creative-design engineer classifications.

III. The Dilemma of the Curriculum

We now find ourselves in an apparent dilemma! We are asked to set up a curriculum that will provide education for several classes of engineers as well as for those who have no intention of entering any area of engineering. The difficulty is further compounded by the fact that many of the students are not mature enough even as seniors to decide what their particular life work shall be.

I would offer the following tentative proposal to meet this seemingly difficult requirement: Let us provide the basic education needed for professional engineering as defined above in the knowledge that many more such professional men will be needed in the future and in the belief, so largely confirmed by past experience, that such education—as much as can be comprehended—will be of the greatest value to all "classes" of the engineering "fraternity" as well as to others who wander from the fold of engineering. At this time it is not clear to me that any other type of education is more helpful as a general preparation for anyone who must find his way in the industrial world of the technological future.

For the remainder of this discussion I would like to present the fundamental concepts or elements which should be used to effectively design sound educational programs for professional engineers.

IV. The Design Elements for a Program in Engineering Education

The first of these is the *learning process.* Under this heading should be considered motivation. Many of our freshmen engineers arrive on the campus with enthusiasm for the enginering profession. Instead of keeping their interest in engineering at a high level, we have a tendency to reduce it by assigning too many non-engineering courses in subjects that seem to the freshman to be unrelated to his profession. At Purdue we intend to alter the freshman year by introducing a basic enginering course which will be designed to increase their enthusiasm for engineering and at the same time show the importance of chemistry, mathematics, and English for later engineering work.

Next come the *laws of learning.* Few of the freshmen have a clear understanding of the learning process, which includes such items as proper study habits, retention curves, etc. In order to introduce them to these important matters and at the same time strengthen their interest in engineering, we expect to use concepts such as a circuit analogy, etc. In so doing we will be able to show these essential factors in terms of an engineering system.

We hope to present to the student many experiences in deductive and inductive reasoning starting in the freshman year. It is felt that by careful integration of subject matter considerable success will be achieved. Every effort will be made to impress upon each student the importance of education as an individual affair. The student must be persuaded that if he does not have the basic desire to learn, his failure is inevitable.

It is hoped that during the four-year period we will be able to impress upon him that life-long learning is essential for true success. Too many of our graduates feel that commencement is the terminal point in their education.

According to our studies the second basic element to be considered in the design of the enginering curriculum is the development on the part of the student of a keen *appreciation of the languages*

of engineering. The basic language is, of course, the native tongue. A reading knowledge of one or more foreign tongues would be advantageous. One of the fundamental needs, therefore, is greater facility in the use of English—both oral and written. Few of our students are afforded an opportunity to develop skill in oral expression. A study of this matter will enable us to improve existing procedures.

The pictorial aspects of the modes of expression by engineers are drawing and sketching. Engineers need not devote hours to the development of skill in producing precise drawings, as this is becoming the realm of the technical institute graduate known as the draftsman. Engineers should be proficient in sketching so that they can rapidly portray their ideas to the draftsman or machinist.

The symbolic phase of the language of engineering consists of the students' skill in mathematics as applied to engineering. Mathematics is a tool used by engineers, and as such should be taught as an application course.

The third design element of an engineering curriculum is the *understanding of natural laws and concepts.* Greater integration of subject matter is required in the basic engineering courses. The natural laws presented in physics, chemistry, psychology, etc., should receive greater emphasis.

In many of the technical courses considerable time is devoted to studies of existing engineering equipment. Our goal is to develop capable engineers for the design problems of tomorrow. The equipment of today may become obsolete; hence time devoted to detailed descriptions could be more effectively used on enhancing the students' understanding of basic principles.

The fourth design element is *appreciation of engineering* as defined.

Engineering is both an art and a science. All problems in engineering are not solved by means of equations or technical data. In many instances a great deal of experience is required. Oftentimes the force fields are so extensive that one cannot deal with them by analytical methods. For example, in making the final selection of the site for a dam the chief designing engineer must utilize his wealth of background knowledge together with the information from reports prepared by specialists such as: geologists, soil mechanics experts, meteorologists, structural designers, economists, electrical distribution engineers and flood control experts. During a four-year program of undergraduate study it is not possible to teach the student the art of engineering; however, he should be made aware of its importance.

The fifth design element is the *general mode of analysis.* Ideal and actual systems should be distinguished from one another.

The essential steps of the general mode of analysis are: (1) preparation of statement, (2) establishment of the ideal system, (3) specification of the boundary, (4) application of fundamental laws and knowledge, (5) prediction of the behavior of the actual systems, and finally (6) study of additional systems. Of course the general mode takes on special forms in particular areas of application.

There are four general methods of attack: experimental, analytical, the use of models and analogs, and finally what might be called art. By art I mean the application of judgment based upon experience.

The sixth "design element" is that of *laboratory experiences.* During the four-year program the student will work in many different laboratories, ranging from the open campus in which he performs his freshman surveying work to the power plant where he tests a complete engineering system.

The seventh element is *knowledge of the properties of materials used by engineers.* The engineer is always confronted with the wise use of materials, and, in addition, he must eventually have an understanding of their costs and availability. Throughout his educational program the student

should receive instruction with respect to the many types of materials used in the fabrication of engineering systems.

The eighth element is *skill in mensuration and computation.* The engineer is required to be familiar with various types of measuring instruments and their use. The proper measurement of such variables as time, distance, area, pressure, temperature, resistance, voltage and flow is a vital part of the engineer's storehouse of knowledge. The exercises in the surveying courses constitute an experience in the use of instruments for measuring lengths, areas, and angles. During any laboratory period the student should take every opportunity to acquaint himself with all types of instruments, such as electron microscope, spectrograph, oscillograph, transit, chronograph, and strain gage equipment.

The engineer is constantly confronted with several systems of symbols and units used for the designation of the physical quantities. Since no standard set of symbols or units have been agreed upon by all engineers, the student should begin to develop skill in transferring from one system to another. He should not complain when one instructor uses one set of units and another a different set. He must accept this as a challenge to develop skill in understanding all of them.

By their very nature engineering problems require computations; hence skill should be developed in the use of computers. The engineering student often starts to use a computer in the sophomore year, the slide rule. He should be encouraged to become familiar with all types of computers in use on the campus during his stay at the university.

The ninth element is *knowledge of regulation and control.* All modern engineering machines, processes, and circuits involve some kind of control or regulating instruments. The student should be encouraged to study the types of instruments and controls used in all parts of systems; for example, in a modern automobile one finds: the ignition switch, gearshift mechanism, speedometer, oil gauge, battery charge or discharge meter, fuel gauge, light switches, etc.

Many opportunities should be afforded the student to observe control systems in the laboratory. Inspection trips should be arranged to industrial plants for the study of actual regulation and control systems.

The tenth element is acquaintance with *industrial processes.* Modern industry uses a multitude of processes for the manufacture of end items. It is essential that the student have an appreciation and understanding of some of these. In the limited time available, it is possible only to introduce the student to a few of them in the laboratories, such as the manufacturing process laboratory.

Students should be encouraged to take full advantage of inspection trips and to seek summer employment that will enable them to become acquainted with the operation of some of the important industrial processes.

The eleventh element is *appreciation of values.* Before he can enjoy the status of a respected citizen in his community and become a worthy member of his profession, the engineer must have developed an appreciation of certain values: human, moral, social, artistic, economic, and professional.

He should endeavor to understand the actions of his fellow men and try to realize why they behave as they do before the problems which confront them, and with this understanding should come good will. He should seek to recognize and to cultivate truthfulness—honesty—integrity—especially in intellectual areas such as his own work. He should develop a strong sense of loyalty—to his fellow workers, to his employers, to his profession, to his country. He should contribute his best effort toward the various worthwhile cooperative undertakings in his community. He should develop an interest in school systems, local governments, etc. As a good citizen, he should study current events and take seriously his obligation

to vote. He should seek an understanding of music, art, drama, etc. This will help him to appreciate the aesthetic qualities of his own work as an engineer. The student should develop an appreciation of economic values; for example, the value of new discoveries and inventions. Indeed, without this he cannot be an engineer. Every student and engineer should have a pride in his profession and contribute ideas that will help to enhance the standing of engineering. The student should be encouraged to join a student engineering society before graduation and to take part in its activities, seeking, if possible, to improve them.

The sense of value is an awareness and a conviction that one gets from others who have it. It can be shared but not legislated into existence. The opportunity of the college to help the student in this area therefore depends primarily upon the teachers—the quality and intensity of their sense of values. The curriculum, itself, is of secondary importance.

The final element of my list is the *integration of subject matter for design.* As the student progresses he should be encouraged to be on the lookout for ways and means for correlating and integrating fundamental knowledge. The more of this he can do, the stronger his foundation will be. For example, there are certain basic laws and relations which describe the flow of electricity in a circuit; many of whose equations apply also to the flow of a fluid through a pipe or the flow of heat through a building wall. The techniques for solving the one set of equations are, of course, essentially the same as for the others.

When or if we succeed in combining in proper proportion and emphasis the twelve basic elements herein proposed, then we shall have developed an appropriate curriculum for the engineers of the unpredictable but almost certainly trying times just ahead.

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National Science Foundation Offers Graduate Science Fellowships

College seniors and graduate science students can submit applications for the more than 750 fellowships for a year of graduate study during the 1956–57 academic year. Applications can be obtained from the Fellowship Office, National Research Council, Washington 25, D. C. Closing dates for receipt of applications are December 19, 1955, for postdoctoral applicants, and January 3, 1956, for graduate students working toward advanced degrees in science. Selections will be announced March 15, 1956.

Where Are We Going in Engineering Education?*

By R. L. SWEIGERT

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In any discussion of engineering education there appears to be two points of view possible, one of which leads to education for a learned profession, the other, to a general type of education that is supposed to be good preparation for a variety of activities.

A letter that I recently received asked this question about engineers: are we tradesmen, technicians, or members of a learned profession? This question is going to be answered as time passes whether or not those of us concerned with engineering answer it. Outside influences will produce an answer for us if we do nothing or little about it, and we may not like that kind of an answer!

Our unwillingness to have provided an answer to the question is helping the movement towards unionism and unionism can hardly be classified as part of a learned profession. A leading labor-leader before a Senate Committee stated that he had been unable to find any distinction being made between the technician and the engineer, and that as far as he was concerned, the technician, the engineer, and the man working at a lathe were all the same.

If engineering is a learned profession, and I believe that it is, then it can be defined in terms that will indicate such a condition. Before we can proceed with the development of a better profession and better professional engineering education, the profession must be explicity defined. Without it being carefully defined how can we carry forward engineering education? If engineering education is to be preparation for a profession then what must be the prime consideration.

I would like to point out two things. First, there has been no scientific type of evidence that shows that engineering education is a good preparation for most anything; and second, there is no other place for one to get a professional engineering education than in an engineering school, but there are other educational places for those entering other types of activities. Therefore our prime concern should be for the young man who desires an education that will prepare him to become a professional engineer and this should receive first consideration regardless of the fact that we will always have a number particularly at the undergraduate level who will go in other directions. Some professional engineers may become administrators. Administration should not be regarded as the end point for a professional engineer. If engineering is to be a worthwhile profession, it must stand on its own feet. Young men should enter the study of enginering because they have a strong desire to be professional men of the highest competence in the practice in the profession. If its function is to be a stepping stone then it doesn't deserve a place amongst the learned professions. We will not have the profession that we should have until our engineering education is directed primarily towards preparation for the profession and we

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look upon becoming a top engineer as a final goal in itself. Engineering should and can stand upon its own feet.

Now how can we define engineering so that it will show that it is rightfully one of the learned professions? To be a profession there needs to be something distinctive about it. Careful examination shows that design is a prime characteristic. But there are all kinds of design. Therefore it must be carefully specified. We can say that professional engineering includes the functions of research leading to design; development, which naturally leads to design; and creative design based upon the application of mathematics, the physical sciences, and any other appropriate sciences. I believe this definition makes the profession of engineering distinctive, separating it from technician level work and from the work of the scientist. It also indicates the characteristic of a learned profession involving extensive educational preparation. Professional engineers may perform professional work in other functions where the same full knowledge of design is called for. Such functions however should not be classified as engineering functions. Professional engineering is creative and covers design of devices, systems, and processes.

The work of the technician with which professional engineering practice is frequently confused, is different. It is not creative but is routine and repetitive in character. Technicians function in operation, maintenance, service, production, installation, and sales. They follow the professional engineer's instructions and perform repetitive calculations and other repetitive operations.

I suspect in the light of the definition above the engineering schools have turned out a high proportion of technicians. Two year Technical Institute graduates can take over many technician jobs bnt we also may need a number of four year technicians, and it becomes a problem of the future whether or not we should train technicians in professional engineering schools although probably there will always be a number of four year men who may not be able to become professional men and therefore can perform a much needed work at the technician level.

Becoming More Scientific

As we note the direction that the engineering profession appears to be moving, that while it remains an art, it is nevertheless becoming much more scientific. As science advances the profession must also advance in the same way or otherwise the scientist must step over into the engineering field as has frequently been the case.

Coming back to our definition, if it is accepted, then we have the direction indicated that our engineering education programs should take.

It is evident that if we are concerned with design based upon mathematics, the physical sciences and other appropriate sciences, then our programs should provide that background in such a manner that it is useful; that means giving at least an amount upon which one can build effectively.

Certain sciences due to their extensive engineering use have become known as engineering sciences. There are six of these of importance to prospective engineers at the present time and therefore of importance in engineering education. These engineering sciences call for a background in mathematics and science. The engineering sciences should be given using the sciences and mathematics.

Following this background the student should be prepared to take up analysis and be initiated into creative design. It should be noted that the undergraduate student can only be introduced to the engineering sciences in a four year curriculum, and the creative design courses are naturally limited to this introductory level. The four year program is preparatory, not professional.

While the suggestion of bifurcation seems to be thoroughly frowned upon, nevertheless the idea continually rears its head. We are confronted with two classes of functions for which we have

been preparing young men; the professional functions already mentioned and such other broad non-professional functions as service, operation, maintenance, sales, engineering aid, etc. These differences can be provided for by electives which in operation then become equivalent to bifurcation. Those not going into strictly professional functions do not appear to need as much science, mathematics, or engineering science, while those with professional objectives would need the science and mathematics.

An appropriate sequence of general subjects is also part of the educational picture but if we keep in mind Sir Richard Livingston's philosophy we will not dilute our programs to the extent of harming the strictly professional preparation. Sir Richard Livingston is an outstanding liberal arts educator in England. He states to profit from liberal studies, a student needs a life background upon which to understand and interpret such studies. Maturity is essential. Liberal studies should receive more attention at the graduate level. At present they receive almost no attention.

Since the preparation that we have been talking about is essentially preprofessional, it must be followed by advanced professional study at the graduate level or by equivalent individual study. Young men with the necessary energy, drive, and persistence can gain this professional education themselves but I believe that it will become more and more apparent to such men that they can gain their objectives better by graduate study in engineering at a qualified engineering school. Let us move in the direction of adequate and full preparation for the profession. The pressure for off-campus graduate work in engineering shows the need for this preparation.

Before leaving the discussion of programs I would like to refer again to the fact that the principle background for engineering comes from physics, and chemistry with the use of mathematics as a tool.

With this condition, at the undergraduate level we might need to be confronted with only two programs, one based primarily upon physics and one based primarily upon chemistry. This would eliminate the fragmentation that we now have.

Such undergraduate programs would give excellent preparation for professional study at the graduate level where the students would enter more specifically into mechanical, electrical and other applied fields. Professional graduate study should be essentially advanced study of appropriate engineering sciences along with work in creative design and research. Through the thesis we can perhaps approach as closely to the art of engineering as can be done on a campus.

Shortage in Brainpower

We should be concerned about a shortage in engineering brainpower rather than a shortage in bodies. We have not educated our prospective engineers to the level to enable them to function the most effectively in modern engineering practice.

We have done all right in training technicians and a rather high proportion of our Bachelor's men have become technicians. They are doing a needed work but are not creative.

We need the right combination of students, faculty, facilities, programs, and money to produce the most effective education possible for professional engineers and also for four year technicians which undoubtedly we will continue to train for some time. What finally may be the full impact of technical institutes is not clear, but their development may change some of the things now going on in engineering schools.

We need better students resulting in reduced attrition, more professionally and scientifically minded faculties, more creative faculties, more scientific and fuller developed programs to the top level, and appropriate facilities to develop understanding, know-how, and creativity.

Perhaps we can make a rough comparison between 1900, 1950, and the year 2000. In 1900 most of the engineers had no college education and perhaps a degree was looked upon with some disfavor. Today, Bachelor's degrees are the rule and the doctorate is the more rare level to-day.

If some of the present trends continue, by the year 2000 it is quite possible that professional engineers will be coming out at the doctorate level.

Then because of the extended period of education and a recognition of its level, engineering will become much better recognized as a learned profession which it appears difficult to bring about to-day. It will be much easier to separate union activities from the profession.

Let us put aside that part of tradition that holds us back and let us advance engineering to a recognized unified learned profession. This we can do if we all put our shoulder to the wheel. Let us all look to the future to one of the finest of the learned professions.

College Notes

A teaching professorship in chemical engineering, believed to be the first industrially-sponsored university chair specifically limited to undergraduate instruction, will be established at **Cornell University** with funds given by Socony Mobil Oil Company, Inc.

Dr. Charles G. Overberger has been appointed head of the Department of Chemistry at the **Polytechnic Institute of Brooklyn.**

A Department of Industrial Engineering has been added to **Stanford University's** School of Engineering. Professor W. Grant Ireson will head the new department which offers studies leading to degrees of bachelor of science and master of science in industrial engineering.

The Place of Solid State Physics in Engineering

By H. V. FAIRBANKS

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Introduction

Much is known about the laws which govern gases and liquids, but only in recent years has extensive work been done to discover the laws and in particular the mechanisms which govern the behavior of solids.

In engineering, solids are one of our major materials, if not the major material, with which we work. For years we have dealt empirically with such properties as creep, fatigue, corrosion, electrical resistance, magnetism, wear, hardness and strength of materials. Today through the use of solid state physics, we have been able to approach some of our problems in a more direct scientific manner. And as our basic knowledge in solid state physics increases, more problems are solved and better yet, new applications for the solid materials are found.

This shift of the technical base of engineering from one which was largely empirical to one which is scientific has increased the importance for engineers to be well grounded in the basis sciences. The body of scientific knowledge in these fields, as we all know, is growing very rapidly. But of more importance to the engineering profession is the equally rapid decrease of the time interval between a discovery in pure science and its practical utilization.

History

In regard to solid state physics, let us take a look at the developments over the past years which have helped to create this important branch of science. Starting back in 1869, we find that Mendelyeev arranged the elements according to their atomic weights into a chart known as the periodic table. From this arrangement, the periodicity in properties of the elements were noted. This led to predictions as to what properties one might expect when the elements were added to a metal to produce an alloy.

In 1876 Gibbs formulated his phase rule which has aided us in our knowledge as to what factors influence a given system. Among its many uses, it has served to define the eutectoid as a point instead of a line on the iron-iron carbide phase diagram.

At the turn of the twentieth century, many scientific discoveries were made which have had a direct bearing on our present day science of solid state physics. Among these are Rontgen's observation that cathode rays impinged on matter produced X-rays, Madame Curie's isolation of radium and study of magnetism, Thomson's experiment which proved that cathode rays were made up of negatively charged particles, Plank's quantum theory, and Einstein's famous equation relating energy to matter.

With this as background, Lord Rutherford in 1911 conceived the modern nuclear theory of matter. Two years later, Bohr expanded this theory by introducing the idea of energy levels for the electrons. Lorentz in 1916 extended the theory of Drude for the solid state of metal. His theory stated that metal crystals are made up of ions which are held together by a free electron gas.

In 1925 wave mechanics was introduced for the study of the mechanism of atoms. Also in that year, Pauli announced his exclusion principle which stated that no two electrons in the same atom may have their four quantum numbers identical. During this same year, Hume-Rothery

formulated his famous rule of electron concentration which generally determines the type of crystal lattice system for metals in the solid state. For example, the electron to atom ratio of 3:2 is found for a body centered cubic; and a 7:4 ratio for a close-packed hexagonal structure.

In 1938 the theory of metallic bonding was greatly expanded by Pauling. He stated that the electrons which bind the metal ions together are in resonance between the ions due to the fact that there are unfilled orbits in the metal atoms.

Within the last 20 years, several symposiums and conferences have been held, and numerous articles and books have been written upon the subject of the solid state of matter. The most recent ones have dealt with the imperfections found in the solids. Many explanations have been made to show how these imperfections affect the properties of the solid materials.

Applications

Now let us look at some of the applications that have come from these theories. The constant value of resistivity of Constantin over a rather large temperature range has been found to be due to the release of trapped electrons by nickel in the third layer as the temperature of the metal is increased. The low coefficient of expansion of Invar over a given temperature range makes use of the contraction effected by part of the material changing from the magnetic state to nonmagnetic state which offsets the normal expansion caused by raising the temperature. Making use of this knowledge, other alloys have been fabricated which have better properties than either Constantin or Invar.

Using our present physical theories, one comes to the conclusion that a perfect metal crystal should have very little if any resistance to passage of electric current. It can also be calculated that metals should be 100 to 1000 times stronger than they are. The question arises: What causes this discrepancy between our theories and actualities?

The answer seems to lie with the imperfections which have been found in the metal crystals. These imperfections give rise to higher than normal electric resistances and weaker than normal strength. The imperfections may be of many kinds, such as impurities, dislocations and vacancies. Recently a method has been used which pretty well eliminates the impurities. These extremely pure metals are found to have lower electrical resistance and are extremely strong when of microscopic diameter. However, for normal sized masses of material it was found that the dislocations and vacancies within a crystal apparently have a definite equilibrium value for any given temperature and pressure.

Vacancies determine the rate of atom diffusion and play an important role in the sintering of compressed metal powders. This is of commercial importance in the fabrication process called powder metallurgy.

As for dislocations, these are extra sheets of atoms which may contain between 10 to 10,000 atoms and are squeezed between but do not go all the length of the regular layers of atoms making up the crystal lattice structure. They produce stresses in the areas where located and make voids in the end spaces adjacent to them. Foreign atoms migrate to these areas and fill the voids locking the dislocations into place. This factor of locking dislocations into place is what causes the horizontal wavy portion of the stress-strain curve for mild steel when the proportionality limit has been exceeded. The explanation is as follows: (1) The stress applied to the metal causes the dislocations to move. (2) However, they are initially locked into place by the carbon atoms; therefore, a more than normal amount of force is required for the dislocations to move. (3) When once moved they then move easily until they replace the position of another dislocation. (4) The carbon atoms again lock the dislocation in place and as the plastic deformation proceeds, the process is repeated several times.

It has been estimated that under equilibrium conditions or in the annealed state 10^8 dislocations are found in a cubic centimeter of a metal crystal. After severe cold working, 10^{11} dislocations per cubic centimeter are present. Plastic deformation, therefore, not only moves the dislocations but increases the number of dislocations present in the metal. These dislocations move along many directions within a metal crystal and meet like automobiles at a street corner until there is a traffic jam. The resistance of dislocations to move across each other at these traffic jams causes what is known as work hardening of the metal. If further stress is applied, dislocations can be made to cross each other and large voids are formed. These voids may be seen at the break of a bar of rectangular cross-section which has been pulled in a tensile strength machine.

We at West Virginia University are carrying on a research program in which we are measuring the amount of voids created by cold working of the metal through tension. This is obtained by measuring the resulting decrease in density and checked by X-ray diffraction.

The theory of dislocation also explains why metals are not as strong as calculated. The mechanisms of movement of a dislocation is one which involves 10 or more adjacent atoms instead of a whole plane of atoms. In order to produce a movement of one atomic spacing both the top and bottom layers of atoms move and each atom involved may move only $\frac{1}{20}$ of an atomic spacing. This greatly reduces the force required for the plastic deformation. This mechanism of movement also accounts for the fact that metals do not fracture when deformation takes place.

Let us now turn our attention to other phenomenon which have been aided by solid state physics. It has been found that the first stage of creep may be considerably reduced by putting in low angle grain boundaries and by coarsening the grain structure. This may be accomplished by prestressing the metal 3% followed by annealing. In the field of electrical engineering power losses in transformer, motor and generator cores are being reduced by crystal orientation of coarse-grained 3.5% silicon sheet. The processing is similar to that just mentioned.

In the field of plastics, we find that the solid state may be amorphous, crystalline or a combination of both. If the plastic forms a floppy chained polymer, it tends to be amorphous. If the polymers have a regular structure, it tends to be crystalline. When testing the tensile strength of plastics, we find that there are three stages: (1) removal of the initial slack, (2) straightening of the chains, and (3) slip of the chains past each other. Recently a chemical company has been able to control the crystalline structure of nylon. This allows the nylon to take on added properties and opens up new fields of application for it such as, gears, bottles, valves, and machinery housing.

In another field of solids, we find that water is the solidifying agent. In concrete there are two types of water present: (1) gel water which is the water of hydration and (2) capillary water. The amount of gel water accounts for the shrinkage and expansion of the concrete due to temperature changes.

The amount of extra water used in concrete mix determines the number and size of capillaries. The larger the capillaries the weaker becomes the concrete therefore, it is best to have as dry a mix as possible. Also it is the freezing of the capillary water that causes concrete to crack in winter. To remedy this, we put air bubbles in the concrete which allows for the expansion of the freezing capillary water.

Solid state physics has played an important part in the development of many fields which have been well publicized such as nuclear energy, magnetism, transistors, solar batteries and the light amplifier. This is only the beginning of many applications to come.

Where in Curriculum?

Now the question arises how and where can we put the material of solid state physics into an already crowded engineering curriculum. An answer may be found from the report on the Carnegie Conference on the Impact of Solid State Science on Engineering Materials.* The following suggestions were made:

A. Enrichment of existing courses in the curricula with solid state science material.
B. Replacement of a specific portion of the present appropriate courses with up-to-date material.
C. Utilization of available advanced physics courses as electives.
D. Establishment of specific new courses in solid state physics.

It is my thought that the Physics Department should handle the pure science phase of the solid state by incorporating this subject matter into the regular physics courses. I am also in favor of having 3 or, better still, 4 semesters of fundamental physics required for all engineers. A few schools have been doing this for several years.

The applied phases of solid state physics should be taught by the engineering instructors. This means possible replacement of a specific portion of some courses with up-to-date material. And in other cases, it would mean enrichment of existing courses with applications of the solid state science.

To emphasize my point of view, I would like to quote from Dr. N. H. Frank, Head, Department of Physics, M.I.T. from a recent article published in the *Journal of A.S.E.E.*†

> In short, physics courses should be pure physics and applied physics should be taught by the engineers . . . clearly the mere addition of the factual matter of modern physics and of modern physical theory to the traditional courses can lead only to dilution and superficiality. I submit that we need surgery; we must be willing to cut out much of the traditional, albeit solid, subject matter of physics, use modern physics to supply the illustrations of the basic principles, shift the emphasis to the broad conservation principles and their implications, integrating them into a unified structure, and drop the conventional divisions of physics.

On the engineering side of the picture we have a similar job to accomplish. There should be a re-evaluation of courses and their content. A lot of so called solid material could be removed and replaced with up-to-date subject matter. The tools for engineering are changing. As was stated before, the technical base of engineering is changing from the empirical to the scientific. Engineering education must therefore change to keep pace with the times and to provide these new tools which are so necessary to our profession. As to the actual integration of solid state physics into our present engineering curricula, we must face this educational problem in the same spirit with which we face any new problem in engineering.

Conclusion

The present limitations to many engineering developments are a direct result of the limitations in our knowledge of the properties of solid materials. Therefore, it would be well if all engineers could acquire some basic knowledge of the solid state science. It is especially needed for the research and design engineer and is well worth while for the production engineer as he will then be better equipped to make use of the developments which stem from the application of Solid State Physics.

* G. Murphy, "Report on the Carnegie Conference," *Journal of Engineering Education*, Vol. 45, No. 5, Jan. 1955, p. 418.

† N. H. Frank, "The Responsibility of the Physics Teacher in Engineering Education," *The Journal of Engineering Education*, Vol. 45, No. 3, Nov. 1954, p. 243.

Recognizing Potential Engineers Among Science Students

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The Situation

America is facing a dire shortage of scientists and engineers. This has been the subject of numerous reports by such writers as John M. Gillette, Harley M. Kilgore during the second session of the 79th Congress, M. H. Trytten in *The Scientific American,* and the National Manpower Council. Comprehensive and detailed studies by many investigators have shown that scientists are different with enough specific character traits to make identification easy. Career choices for science are made while the student scientist is young. It is this writer's opinion that a way must be found to identify the future scientist before he makes his career choice and thus interest him and guide his training so that all potential future scientists are developed to their maximum capacity. Information from the Science Clubs of America has shown that 94 per cent of the winners of the Science Talent Search followed their occupational choice and became scientists, engineers and professional people. It appeared that these were a few of those rare key people, yet in the embryo state. The identification and classification of their characteristics and background factors became the problem to solve.

The Procedure

Developing the instrument.—By utilizing the findings of all previous studies, the writer's personal experience, the opinions of consultants, pilot studies of trial and error, an inquiry form of 300 items was developed. The writer received invaluable help from the creators of the Science Talent Search and Science Clubs of America in developing the instrument and sending it to the respondents. These were mailed to the respondents and the return after two months was 85 per cent.

The respondents.—There were two groups of respondents, as follows:

A control group of 78 freshmen and sophomores of high general ability. Their IQ mean was 129. In many ways they were similar to the test group, however, they were generalists rather than specialists in science.

A test group of 600 freshmen and sophomores of high special ability. Their IQ was not known accurately but suggested to be around 140. These were the Winners and Honorable Mention Winners of the Science Talent Search for 1952 and 1953.

Analysis of the data.—The IBM answer sheets for the questions in the inquiry form were sorted according to occupational choice making five groups: scientific scholars, potential scientists, potential engineers, women in science and potential professional people. The responses were tabulated electrically by an IBM item tabulator. The total "yes" responses for each question were converted to percentages. The percentage response of each of the five sub-groups and the whole test group (504 superior science students) on each item was compared with the similar response to the same item-answer by the control group. The differences in percentages were tested for significance by

TABLE I

OCCUPATIONAL CHOICES 110 ENGINEERS (POTENTIAL)
HONORABLE MENTION, MEN

Title of the chosen occupation (1)		No. sub. per cent (2)	No. total (3)	Per cent (4)
Engineer, electrical			36	32.7
Engineer, electrical unspecialized	15	13.6		
Engineer, electrical electronic	16	14.5		
Engineer, electrical auto control	5	4.5		
Engineer, chemical			29	26.4
Engineer, mechanical			9	8.2
Engineer, aeronautical			9	8.2
Engineer, physics (combined)			8	7.3
Engineer, nuclear			5	4.5
Engineer, unspecialized			5	4.5
Engineer, architectural			3	2.7
Engineer, industrial			3	2.7
Engineer, civil			2	1.8
Engineer, geological			1	.9
Totals			110	99.9

the methods of Palmer Johnson.* Multiple choice items were analyzed by Chi Square. Items of significance at the five per cent level or more were selected as qualifying items of characteristics and background factors.

Results

Tables and portraits.—The occupational choices of the test groups, Table I, and the control group, Table II, were tabulated and reported. These verified the interest of the respondents in the special field of science and the general field of life activities. There were over 150 of the 300 items that were significant at the five per cent level for all groups. Many were related to each other being merely different aspects of the same quality. They were, therefore, grouped into eight general categories: personality, attitude, interests, activities, family history, associates, science teacher and decision for science. The items in each category create the portraits of the superior science students and their own sub-groups.

Characteristics of Potential Engineers

The portrait appearing below describes those characteristics and background factors of 110 Honorable Mention Winners of the Science Talent Search who have chosen engineering as their profession. These items are significantly different at the five per cent level from those characteristics and background factors of their contemporaries in general education. The portraits were developed like those in other studies by grouping significant items under related general categories. The number following each item shows the *percentage* of the group that responded positively to it.

Personality

The potential engineers appeared to be *leaders* for they enjoyed being group leaders in science 69, they liked to assume responsibility 80, to organize and lead field trips 64, hold office in a science club 42, or be elected an officer in student gov-

* Palmer O. Johnson, "Statistical Methods in Research," Prentice-Hall Inc., New York, 1949, p. 165.

ernment 43. They were *self-disciplined* and had good control of themselves, they did not attempt more than they could complete 72, made a determined effort to always be punctual 75, did not depend on their own memories to be unusually reliable 58, did not dislike hard work and long hours on self-assigned tasks 88, did not have occasion to regret losing their tempers 61. They were *serious minded, practical and materialistic,* they did not find people calling them day-dreamers 70, did not have dates with girls as often as twice a week 93, did not want to be like athletes 94, but they liked to solve mental puzzles and riddles 84 and usually sought causes for all effects 72, they had a *lively curiosity* about the natural world 89.

Attitudes and Opinions

The potential engineers have an *attitude of suspended judgment* for though they usually persisted tenaciously on a job to its completion 65, they quickly changed their opinion if proved wrong 78, and they consciously separated their judgments from their likes 78. They are *not solitary and self assured* in their outlook for while they always gathered their own facts 37, they got real help in science from someone else 72, and did not conclude that a person is responsible to himself alone 90. They believed in *no superstitions* 91, did not participate in the usual games of chance 59 and did not let events of chance plan their lives 78. They are *not agnostic or atheistic* for they do not question the soundness of religion 49 and willingly go to church twice a week or more 88. Their *social views on the application of science* are a bit unusual for they question the use to which science is put 77, decided that scientists and science students were so scarce and so valuable that they should not be drafted for military service but kept in their scientific work or study 56, but at the same time scientists should not ignore promotions 96.

Interests

The interests of the potential engineers are *rather narrow and specialized.* They are *partly mechanical* such as an interest in radio-ham operating 76, hi-fi and radio set building 81, handwork, crafts and

TABLE II

OCCUPATIONAL CHOICES—78 CONTEMPORARIES IN GENERAL EDUCATION (CONTROL GROUP)

Title of the chosen occupation (1)	No. total (2)	Per cent (3)
Undecided	19	24.0
Writer-journalist	11	14.1
Teacher, college or high school	9	11.5
Businessman	6	7.6
Entertainer, radio-TV	5	6.4
Dentistry or medical practice	4	5.1
Lawyer	4	5.1
Civil service	4	5.1
Psychologist	4	5.1
Engineer	3	3.8
Scientist	3	3.8
Social worker	2	2.6
Medical service (female)	2	2.6
Theologist	1	1.3
Secretary	1	1.3
Totals	78	99.9

carpentry 89, mechanics, tinkering and repairing 92, model building, boats and planes 76, photography 87. It is *partly scientific* such as an interest in reading science 97 and science fiction 69, inventing 95, and science studies on projects 95. It is not surprising to find that they are also interested in *scholarly things* such as a study of courses in school 79 and playing chess 73, outdoor life in scouting activities 74 and astronomy 83.

Activities

The activities of the potential engineers are the behavioristic expression of their attitudes and opinions, interests and personalities. They had some *general social* characteristics such as membership in non-scientific clubs 90, elected officer in student government 43, work on school publications 59, membership in four to eight clubs, committees and societies 57, but no athletic team membership 51. There are some activities that reveal their *scholarly* characteristics such as belonging to an honor society 82, never failing a course 93, never expelled for disciplinary reasons 97, accumulated less than a total of a month's absence during high school career 85, on the honor roll 100 per cent of the time 77, and received marks that averaged A− to A+ 81. They failed to make their best marks in English 97 or their worst in mathematics 94, which they liked 91. As expected *most of their activities were in science* where they were officers of science clubs 42, belonged to Science Clubs of America 30, Junior Academy of Science 19, and scientific societies 55. They spent time regularly each week in after school science studies 46, where they planned experiments and did them themselves 80, performed some high grade scientific research 24, improved a scientific method or device 32, invented something scientific 28, published a scientific or other article 15. These activities usually *led them to compete* in science fairs 34, or congresses 22; compete for prizes in science 74, which they won 58; and a part time job in science 18. In the classroom during school hours they acted as teaching assistants 39, gave lecture demonstrations 57, helped operate audio-visual aids 59, led and organized field trips 20, went on field trips 64 and visited scientific industry 65.

Factors that were found in their backgrounds.

Family History

The potential engineer was *the first born child* 69 and *had no brothers* 55. Among *his older relatives were some scientists* 26 *and teachers* 53 but no musicians 80. His mother was born in America 85, had a college or post graduate degree 36, had *earned the admiration and respect of her son by her achievements* 82 and *did not "boss" the family* 25. *His father* had a post graduate degree 20, *was an employer managing his own business* 37, his *son admired and respected his father's achievements* 84, and the father *did not "boss" the family* 25. The family provided a *stable, comfortable and stimulating home.* The principle residence was *in a city of a million or more* 26, during high school the *family did not move or cause the student to change schools* 89. The family *bought six to ten magazines each month* 52, there was usually a home workshop or laboratory 63, *adequate workshop* or laboratory facilities were available 57, *a place to study* science at home 69. The student had *time to study* and work in science for he had leisure time to study science 86, almost enough time to study science at home 75, and did *not have an after school job* 55. The family highly praised and respected science 61 and strongly *supported the potential engineers' plans* for a career in science 74.

Associates

While the potential engineer read he found that newspaper or magazine *articles could influence him toward a career* in science 40, and that *books gave him inspiration* and encouragement to be a scientist 81, his *greatest social influence came from his associates.* He had *chums*

who wanted to be scientists 79, and he had friends *who let themselves be led in group science activities* 32, there were *older students who helped,* guided and encouraged him in his science activities 38. Even though he thought that he directed himself like a "lone wolf" in science 30, he did personally *know a scientist* 43, and *worked with a scientist* 18, and tried to behave like a scientist 38.

The Science Teacher

The science teacher of the potential engineer *quickly gained his admiration and respect* 83, he had a good sense of humor 92, was fun to be with most of the time 78, and enjoyed his job of teaching 92. He was using his greatest ability as a science teacher 52 and had a hobby 54. Probably the *admiration and respect* were based on the fact that the science teacher believed in hard work and long hours for himself 64, he stayed after school and assisted students in their science activities 91, he *gave them opportunities to lead and organize* group activities in science 70, acted as sponsor for science clubs 76. In his classes he used lectures as his principle teaching method 35, but never discussed "The Great Scientists," 48. He was a *practical man* who had an after school job 23, and invented scientific or science teaching devices 25. He *contacted his professional world* by communicating with teachers from other schools 56, with other scientists 38, and membership in professional organizations 43.

Decision to be a Scientist

The potential engineer decided on a scientific career *when he was in high school* 29, because he had a *natural aptitude* for it 48, and it was so *interesting* 39. He felt he *could grow and develop working on important problems* 27.

Conclusions

Reason for separate conclusions.—There are over a hundred items that build the portrait of the potential engineer. The portrait is a complicated one, so each general category of the portrait has been reduced to a few general characteristics. These have been developed by combining and consolidating several items in the category to a single quality.

Personality.—Leaders, self-disciplined, self-controlled and self-critical. Serious minded and practical, curious.

Attitudes and opinions.—Suspended judgment, neither solitary nor self-assured, rational, religious, believe science can solve social problems.

Interests.—Narrow and specialized into mechanical, craftsman, shop interests. Some interest in scholarly and scientific things.

Activities.—Some social life, scholarly pursuits, scientific, mathematical, competition in science world, helped science teacher.

Family history.—First born son, older relatives in science and education, strong mother influence, family democratic and permissive. Father in business, home stable, comfortable, urban, cultured, economic advantage, time and opportunity for scientific development.

Associates.—Books and associates very influential in science. Stimulated and encouraged by a scientist and friends in scientific activities.

Science teacher.—Admirable person, set good example, permissive, practical, professional and democratic.

Decision to be a scientist.—Reached decision in high school because of natural aptitude, interest, and he could grow and develop working on important problems.

Review.—The potential engineer developed because of capacity, interest, freedom and a practical mechanical setting.

How the Report of the American Advisory Mission to Japan for Engineering Education, 1951, Influenced Japanese Engineering Education *

By DR. KINJI SHIMIZU

President, Nagoya Institute of Technology; President, Tokai Society for Engineering Education; and Vice President, Japanese Society for Engineering Education

Professor Clark D. Goodman requested to submit a document stating about the influence of the report of the American Mission for Engineering Education on Japanese engineering education to Mr. Seisuke Inada, director of the Bureau of Universities, Ministry of Education, who entrusted me to write the document. I think I am one of suitable for this work, because I proposed the organization of the Japanese Society for Engineering Education and seven regional societies and after its establishment took management for improving Japanese engineering education in the Japanese Society, in the Tokai Society and in councils in the Ministry of Education. It was hard work to manage societies effectively and in good financial state; the fact, however, was that by sacrificial efforts of several persons all projects went well and smoothly under comparatively good financial state, though not so sufficient. The Ministry of Education recognized the steadiness and seriousness of our society from first and backed us up very earnestly. Some industrial leaders also supported us very eagerly, acknowledging our enterprise as necessary and significant also for their business. Thus our works are on the track and going harmoniously. Now, reflecting the inauguration ceremony of our society, 1952, I remember the words of Dr. Hazen's message, meaning that when those who have sincere concern come together with true desire to improve for education or anything else, progress occurs inevitably. Really seven regional societies are doing their efforts for improving engineering education in each district and not quickly, but gradually we see many symptoms of appearing good educations.

1. The biggest effect of the report was the work of the Japanese Society for Engineering Education 1952 autumn; that is,

a) the report was translated and abstracted by Dr. Kinji Shimizu and the abstracts were distributed to all engineering teachers,
b) each of the seven regional societies held meetings discussing the report,
c) the discussed results at the meetings were inserted in the first number of *The Journal of Engineering Education,* which was published in April, 1953. The work of JSEE above had, I believe, following influences to all engineering teachers;
   1) Reflection for the responsibilities of engineering teachers.
   2) Awakening of their past incorrect idea for the teaching and teaching method.

* (The person submitting Dr. Shimizu's report for publication requested that it be published without editing and the Editor has abided with that request.)

3) Their idea of "research first" or "research almighty" was somewhat amended or balanced a little by good teaching.
4) At any rate, the report was a great impetus for all engineering teachers to think over how to teach or how to improve their education and to give ear to other comments or criticisms from industrial circle or from experienced educators, in spite of their past dogmatic ways.

2. *The Journal of Engineering Education,* published by JSEE twice a year, give always excitations to all engineering teachers. It includes miscellaneous comments or articles by engineering teachers or by engineers, the discussed results at meetings in regional societies, status of engineering education in other countries, data or reports for improving or contributing to engineering education. It is compiled after the Journal of ASEE, but has a special feature of having plenty of data or reports. That we had such a useful journal is an influence of the report of the American Mission.

3. Yearly in July, we hold the annual meeting of JSEE, calling many hundred teachers and engineers together where many important problems on engineering education are discussed and teachers and engineers exchange their opinions and increase their intimacy. It gives always a chance to reflect their teaching and to be ready for improving teaching. This is also an imitation after ASEE, and is an influence of the report of the American Mission.

4. At the annual meeting, JSEE proposes a theme to be discussed at autumn meetings in regional societies, which excites engineers and engineering teachers in the whole country. The discussed results are inserted in the Journal of JSEE.

5. Last year JSEE tried to make the paper competition on improving engineering education, for which 23 teachers sent their articles and two assistant professors won higher prizes, four professors and one engineer got lower prizes. This enterprise is also one method of exciting teachers and engineers, and will be continued for long.

6. JSEE held from the first its principle to work under the intimate cooperation of universities and industries. The Japan Federation of Industrial Managers always assists our work, giving data in industry and cooperating for investigations.

The Tokai Society collected opinions of industrial engineers on improving engineering education for which industry offered good cooperation; as the result, the relation between universities and industries in that district became very intimate, and the opinions served as a reference for improving education. The result will be discussed at the third annual meeting of JSEE at Nagoya.

Other regional societies are also endeavoring to make good contact between universities and industries.

7. Many engineering teachers are striving to improved their teaching and teaching method, and I believe, not so quickly, but gradually Japanese engineering education will make its progress. I am very glad on hearing the evaluation or criticism for engineering graduates from universities which became better year by year.

A Technical Writing Course That Works*

By RAY SWEIGERT, JR.

Technical Writing Staff, State University of Iowa

In the last January issue of this publication is an article entitled "Our Schools Can Teach Writing—If They Are Made To," in which J. H. Wilson, Jr., of the Editorial Branch, United States Naval Ordnance Test Station, analyzes a problem that has disturbed industry for some time. In this article, the blame for the lack of communication skills among scientists and engineers is placed squarely on the shoulders of our educators—and rightly so. Among the graduates of the few engineering schools that teach communication techniques to their students, there is no problem. Yet where the graduates of most engineering schools are concerned, ability to communicate is sadly lacking.

The Engineering College of the State University of Iowa has developed a two-semester course in technical writing. This course is at least a partial answer to this dilemma. In Wilson's article, the problem is broken down into two parts: to teach technical people the fundamentals of writing and to teach them the special mechanics of writing technical reports. The course in technical writing at Iowa has been able to deal with these two parts at the same time. Since the students in the course must be at least juniors, they know already something of basic writing techniques from struggling with the freshman course in communication skills, part of the liberal arts requirement for engineering students; and they have advanced far enough in their professional studies to have something about which to write. The course in technical writing improves and polishes the basic writing skills of the student and at the same time teaches him to employ these skills in writing technical reports.

The Success of the Course

The Technical Writing Staff is constantly modifying the course in order to make it better correlate with the needs of the engineer in industry. These modifications are based to a large extent on replies to letters sent to alumni of the Engineering College after they have been out of school for about five years. Their replies stress generally the need for technical writing as part of the engineering program, and often suggestions are made as to how the course might be improved. Members of the staff often work in industry during the summer and come back to school in the fall with new ideas for the course.

Solving the problem of motivating the students, of convincing them that the skills they learn in technical writing are a necessary part of their engineering knowledge, has been a major factor in the success of the course. This has been accomplished largely through cooperation between the engineering faculty and the members of the English faculty who teach technical writing and who for all practical purposes are also members of the engineering faculty. Technical writing is recognized throughout the College as an integral part of engineering education. Contrary to the situation found in many schools, the English Department itself has been quite cooperative in recognizing the importance of the technical writing pro-

gram and in granting the necessary aid and support for its success.

The engineers who have had the course, if they are proficient in the other engineering skills, are invariably better prepared to meet the demands of their profession than those who have not done any work in the specialized techniques of engineering writing.

A Description of the Course

The first semester of work in technical writing is devoted to the basic mechanics of writing technical reports. Students are first reminded that "non-technical" words may have precise meanings, and they are instructed again in the proper use of the dictionary. They are taught how to explain a definition to someone in what is called an "extended" definition. Later in the course, they are taught to write an essay on some word to show how the meaning has changed with usage.

Students are taught to write clear, concise, precise exposition on technical subjects. The style may often be uninspired and flat because the engineering student with much literary ability is exceptional; but the style must by all means be lucid. The experience of alumni in industry and of the staff members who have worked in industry has been that the bulk of engineering writing does not involve selling an idea, but merely stating facts. The type of communication which must entice the reader is taught during the second semester. Stress is given to the importance of a neat, mechanically correct paper.

The students learn how to describe a technical process; how to give clear directions; how to describe an apparatus and its functions; how to evaluate technical information objectively in writing; how to make objective comparisons; and how to determine whether or not it would be more effective to make an evaluation through comparison and contrast or through an isolated study. They are taught the techniques and functions of classification and the respective forms and purposes of reviews, summaries and abstracts. They are taught to compare and evaluate opinions, news stories, articles from various magazines and the magazines themselves.

A great deal of emphasis in the first semester, as has already been indicated, is given to evaluation and comparison. It is explained to the students exactly what makes good standards for evaluation and how to set up such standards. They are taught that for the purpose of evaluation, standards must be precise and justifiable. They are instructed in the less obvious methods of measurement by such standards. Since a comparison paper requires a somewhat more sophisticated organization than an evaluation paper, the students are taught to make comparisons after they learn to make evaluations. To be sure, a comparison is a form of evaluation and vice versa. But a comparison as such involves two or more items to be tested against each other. The students are taught to make comparisons on similar bases in order to determine the better or best of a group. In general, the chief emphasis in the first semester of work is on logical thinking demonstrated in writing for a particular reader.

The second semester of work allows the student greater freedom of expression than does the first. It has been found, however, that most engineering students do not appreciate this greater freedom. They simply don't know what to do with it. Consequently, there is constant prodding of the student to write in a language which reflects his own personality, within limits of course, and to avoid the use of stereotyped phrases and clichés. Though the writing is still rather fundamental, it is on a somewhat higher level.

One important part of the work is in writing a formal report on some special project that has practical significance. The student must take an actual problem requiring the gathering of real facts and work out a solution, which is sometimes good enough to be used. In other words, the problems are not contrived for the purpose of the course. Since not all

students have access to laboratory facilities, they are urged to choose a project which requires as little actual laboratory work as possible. Many of them, however, are able to write reports on work which they are doing for courses in their respective fields. Since a student would have to write a report on this work anyway, he is often able to combine assignments and write the same report for both the writing instructor and the other instructor. This cooperation helps the student see firsthand that his ability to write is an aid in his professional work. A further instance of such cooperation is that in each of the several departments in the Engineering College, a student who has demonstrated his ability in technical writing is given the job of grading the quality of the writing in reports submitted in that department.

The first report on the project is a description of the problem and its practical importance. A preliminary report is then written which deals with the various possible methods of studying the problem and presents the method which is most likely to be successful in terms of estimated cost, time and results. The students are shown that if the preliminary report is not done well enough to support the recommendations made in it, the project ends right there. The preliminary report must be detailed enough and convincing enough to warrant the sometimes very large expenditure necessary for a solution to the problem. The persuasive elements of the report, however, are not essentially rhetorical, but factual. Though in industry a preliminary report may be a formal report or only a letter, or even just a verbal report, each student must write a formal preliminary report. The format of this formal report is designed to train the students to handle whatever variations they may encounter in actual practice. If the estimated cost, time and results seem to warrant a further investigation of the problem, this preliminary report is followed by progress reports from time to time until the study is complete and a solution has been found. A final formal report presents this solution.

The students are taught how to write articles for a technical magazine. Those articles which are good enough are considered for publication in the student engineering magazine, *The Transit*. Unless the article is unusually well done the first time, it is revised. Further instruction is given in the composition of summaries, reviews and abstracts. Various types of business letters are written: a letter requesting information; a letter of application; a letter accepting a position; a letter requesting a sales interview, and others.

The students are instructed in oral composition. They learn how to get up before a group and describe a technical process with the use of visual aids. They are taught to give directions, to explain how to do something. They learn how to give a sales talk and a report making recommendations. It must be stressed that this is not a course in public speaking as such. There is a Department of Speech at the University for that purpose. This part of the course is designed primarily to train the students to give effective oral exposition dealing with various types of technical subjects.

During the two semesters of Technical Writing, the students write almost continually; there is a written assignment due almost every class period. The students are impressed with the fact that the only way to learn to write is to write and then write some more. Special attention is given to the overt psychology of writing, to obvious adaptation of style and emphasis for a particular reader. During the second semester, a great deal of attention is given to the art of attracting the reader to articles, letters and talks.

An integral part of the technical writing program is the emphasis on illustrations. I use this term to refer to drawings such as flow sheets and orthographic projections, charts and graphs of various

kinds, tables, diagrams of other kinds and, of course, photographs. The students are taught the diverse functions that illustrations may have, such as to emphasize, to summarize, to clarify, or merely to attract the reader. Since the students are given three semesters of engineering drawing prior to the course in writing, the major emphasis is on how to select the subject matter and form of the illustration so as to supplement the report or article. Drawing is considered as a form of communication in itself, but auxiliary to the writing. An instructor from the Department of Engineering Drawing lectures on supplementary illustration at the beginning of each semester. The drawings are graded by a drawing grader on the basis of appropriateness, completeness and quality. In the second semester, illustrations are considered also from the standpoint of how well they lend themselves to publication. The students are taught, for instance, how to make illustrations that are improved through reduction, rather than impaired.

You may argue that this sounds fine as far as the objectives of the course are concerned, but whether or not these things are actually accomplished is another matter. It is not claimed that the course is one hundred percent effective in teaching these various skills. Neither is it claimed that all of these skills are initially instilled in the student during these two semesters. The students have learned in their previous professional studies how to make analyses and evaluations and how to distinguish between opinion and fact. What they have not yet learned is how to organize and present an analysis or an evaluation to other people. At the risk of being somewhat repetitious, let me say that they have not learned to communicate. By the time they have finished this course, they know how to say what they mean so that those on the receiving end can understand. Naturally some learn how to do this better than others do; but I think it is safe to say that every student leaves the course with a much better knowledge of these skills than he had before.

The Four Neglected Aspects of Report Writing

It is pointed out in "Our Schools Can Teach Writing—If They Are Made To" that colleges fall down in teaching at least four important aspects of technical writing. First mentioned is the neglect of the question: *Who is your reader?* Undoubtedly this is a point far too often overlooked in a basic writing course. At Iowa an effort has been made to remedy this oversight; constant stress is given to the proper "slanting" of material.

There is at least one important implication to this matter of finding out who your reader is. Students in a business writing course were told to write papers to be read by a certain group of factory workers. But having never worked in a factory and having very little knowledge of factory workers, most of the students were quite inept at expressing themselves to such an audience. They had answered the question *Who is your reader?*, but so superficially that real communication could not occur. The students in Technical Writing at the University of Iowa are taught that they must have specific information regarding the knowledge and attitudes of their intended readers. The writer must *know* his reader and know him well. The better the writer knows the reader, the more effective his work will be.

This problem is solved by having the engineering students write their articles, reports and speeches for a student audience. A student is in a position to be well aware of his fellow students' general knowledge and attitudes. In some cases the student is told to address his material to other students in his particular field and at other times to engineering students in general.

The second item neglected in teaching report writing, according to Wilson's article, is the use of tables. It has already been mentioned that in this course heavy emphasis is placed on supplementary illustration. Teaching the use of tables is part of this, though perhaps more empha-

sis should be given to tables. Wilson points out that tables require a rigid format depending on very exact classification. It has been found that many students in engineering have no clear knowledge of the process of classification and its functions. They are taught this in the first semester of work.

The article next mentions illustrations in general. The concern of this course with illustration has been pointed out.

The fourth and last item mentioned is the neglect of methods of reproduction. It is questionable whether or not the teaching of methods of reproduction is really necessary to the extent that is indicated in Wilson's article. It is said, for instance, that a report to be reproduced in ditto need not be "combed over" to the extent that a report coming out in hard type and between hard covers should be combed over. The effectiveness of communication depends to some extent on the method of reproduction, it is true; but the actual writing of the report should not be influenced by this, except perhaps indirectly. All reports should be combed over. The person who is to write the report will know the format to be used and will use it; he will probably know very little about methods of reproduction. And the formats will vary from company to company.

The Future of the Course

The course of study in technical writing at the State University of Iowa has the answers to many of the initial problems facing such a program, yet there is a long way to go. It is not a foregone conclusion at this point that certain basic techniques and certain types of reports are stressed as much as they should be. Perhaps some features of the course will be abandoned as they are proved to be useless. The course is always modified from a pragmatic point of view: What do the students need to know? This question is answered partly by keeping in touch with alumni and their industrial employers.

It is true certainly that the basic principles of writing are universally applicable to all kinds of writing. Perhaps the day is not too far distant when every professional school and college will pay more attention to teaching these basic principles and the adaptations which are peculiar to the needs of their particular students.

Army Needs Help on Ordnance Engineering Handbook

Collections of terminologies, glossaries, specialized dictionaries, etc. concerning ordnance engineering are needed by the Army in preparing a comprehensive Ordnance Engineering Design Handbook to summarize fundamental principles and basic design data. The handbook is being written to provide needed information to army ordnance and arsenal personnel and to the engineering staffs of contractors having ordnance design responsibilities.

Corrosion Instruction in Engineering Colleges

By F. E. ALLEN

Development & Research Division, The International Nickel Co., Inc., New York City

During the past decade industry has been paying increased attention to corrosion prevention with the result that much has been accomplished. The engineering profession is also recognizing the growing need for more fundamental knowledge of metallic corrosion through the Engineering Foundation which is endeavoring to establish a Corrosion Research Council. It is becoming, therefore, increasingly important that engineering students have a knowledge of the fundamentals of corrosion and be aware of the problems created by corrosion.

However, information on the attention given to corrosion principles in engineering schools is not readily available, and to obtain information on the current status of this instruction a questionnaire was sent to 141 accredited engineering schools in the U. S. Replies were received from 122 of these institutions and the results are briefly summarized as follows:

Schools offering specific courses in corrosion	37
Approximate number of students taking courses each year	550
Schools that consider corrosion in at least one course	105
Schools with facilities for corrosion research	74
Schools where corrosion research is in progress	34
Students engaged in corrosion research	91
Graduate elective courses in corrosion offered at 29 schools	
Undergraduate elective courses in corrosion offered at 10 schools	
Graduate course in corrosion required at 1 school (ChE)	
Undergraduate course in corrosion required at 6 schools (PetE, ChE, MetE)	

The fact that about 550 students are enrolled in courses covering corrosion phenomena indicates a growing interest in corrosion and an increased appreciation of the need for knowing something about it in several branches of engineering, principally in chemical engineering and metallurgical engineering. At 18 of the reporting schools, these courses are taught in metallurgical engineering or metallurgy departments, and at 13 schools in chemical engineering.

Several hours per semester are spent on corrosion at 105 of the reporting institutions. This instruction, with but few exceptions, is taught without laboratory and is included in various courses. Of the schools reporting, such instruction is given in 119 metallurgy courses, 31 materials courses, 36 chemistry courses, and in 9 miscellaneous courses.

In addition to academic credit courses, 9 institutions reported having sponsored short courses in corrosion for industrial personnel. These courses last from 2–3 days and are conducted at the school using institutional facilities and staff as well as lecturers and educational aids from industrial sources.

It is gratifying to learn that as much attention as revealed by this survey is being given to corrosion in the nation's engineering schools since such problems ultimately become the concern of the engineer. It is also apparent that much more needs to be done both by industry and our educational institutions, especially when the cost of corrosion to the country is so high. It has been estimated that this amounts to over $5.5 billion a year in the United States.* Since corrosion is all loss, whatever can be avoided becomes a source of gain, either financial or from a conservation of metal resources and associated human and energy resources which are also involved.

* "Cost of Corrosion in the United States," by H. H. Uhlig, *Chem. Eng. News*, 27, 2764 (1949).

Nuclear Engineering and Science Congress

December 12–16, 1955, Public Auditorium, Cleveland, Ohio

Members of ASEE are invited to participate in this Nuclear Engineering and Science Congress. It will be the largest and most important conference of its kind ever held in the United States. It is being coordinated by ENGINEERS JOINT COUNCIL for 26 engineering and scientific groups. All the major U. S. organizations concerned with the atom in engineering, science, industry, and government are cooperating in this joint undertaking.

292 TECHNICAL PAPERS

. . . presented by leading nuclear authorities from 16 universities, 13 government laboratories and bureaus, and 34 major industrial corporations, plus England, Canada, Australia, and South Africa.

GROUPED INTO 50 SESSIONS

. . . running concurrently, covering latest developments in nearly every phase of industry, science, and medicine . . . authoritative information made available after the Geneva Conference papers were selected. An average of 4 societies, government agencies, etc., cooperating in each of these sessions.

A LARGE ATTENDANCE IS ASSURED

. . . from government (A.E.C., its laboratories, and others); finance and insurance; management and technical staffs of the atomic industry; members of ASEE and the 25 other groups participating in this joint event . . . plus representatives of non-nuclear industry looking for ideas to use.

INTERNATIONAL ATOMIC EXPOSITION

. . . sponsored by the American Institute of Chemical Engineers, to be held in conjunction with the Conference, December 10–16, 1955.

. . . the latest nuclear developments from all over the United States and foreign countries.

. . . exhibits by virtually every major supplier and service organization in the nuclear field.

. . . models of all major atomic reactors, including an actual research reactor in operation.

. . . the by-products of atomic power at work—industrial, medical, agricultural, and other devices and materials using isotopes.

. . . entirely new educational exhibits by the A.E.C. and selected universities, including new research developments.

FOR REGISTRATION INFORMATION

. . . Write to: Engineers Joint Council
29 West 39th Street
New York 18, N. Y.

EXPOSITION INFORMATION

. . . For full information about how companies can exhibit at the Atomic Exposition, write to:

International Atomic Exposition
931 Book Building
Detroit 26, Michigan

PRIMARY PURPOSES OF THE CONFERENCE

Thorndike Saville, President of Engineers Joint Council, summed up the primary purposes of the Conference as fol-

lows: "The horizons for the peaceful application of atomic developments are, as yet, not even imagined. This highly interrelated family of developments is, as yet, very much in the 'idea for application' stage. Therefore, it is of enormous importance to present to those interested a panoramic view with detail as a proper measure of current opportunity and the vastness of potential. Progress for the Conference indicates that it will be the largest gathering of engineers and scientists ever held in the United States to discuss nuclear energy. As such it will be a major opportunity for the communication of ideas and developments among the many thousands of persons in industry, business, agriculture and medicine, for whom the technology of the Atom is increasingly important."

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The Award consists of $1000, and an engraved certificate.

The Award has been established to encourage younger men who have shown, by their past record, evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive for further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before February 1, 1956, to the Chairman of the Committee on Award, Professor R. S. Paffenberger, Chairman, Department of Engineering Drawing, The Ohio State University, Columbus 10, Ohio. Nominations must be made on forms available from either the Chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statements and claims.

Specialists in Diversification*

By H. A. FOECKE

Assistant Professor of Electrical Engineering, University of Notre Dame

Today is an age of specialization. Engineering teachers, like everyone else in society, are encouraged to be specialists. Certain recent developments in engineering education have made more clear than ever before the need for the recognition of a kind of specialist which might be labeled a "specialist in diversification." In trying to discover the nature and function of the "specialist in diversification" it will be necessary to take a brief look at the system of engineering education as a whole and to describe the characteristics of some of the other specialists who are a part of it.

For purposes of this discussion, an educational system will be considered to be the formal agency which our society has established for the purpose of guiding and inspiring the student in his quest for knowledge, in his journey to a chosen intellectual frontier. That being the case, no matter how far the frontier advances, education in some form will attempt to keep close behind. Formal schooling will end when it is no longer the most expeditious means of speeding the progress of the student to his goal.

Not too many decades ago, engineering education was a relatively simple system. An average undergraduate college student could absorb in his academic career a reasonably large portion of what might have been considered the sum total of engineering knowledge of that day, and he could be brought up to the frontiers of engineering knowledge on a rather wide front. The enrollments were relatively small and the staff correspondingly few. The functions of administrator, counselor, teacher, professional engineer were all to be found to some degree in each staff member. There was little specialization in the sense we know it today. This was equally true in the subject matter areas where there were relatively few special teachers for special subjects. The distance between the beginning and the end of what could be called engineering education was short, relatively speaking.

By contrast, in the system of engineering education today, there are many specialists. Not only are the functions of research, teaching, administration and guidance and counseling more sharply differentiated and concentrated in certain staff members, but in the subject matter areas there are many more special teachers for special subjects than in the early days. The basic reason for this increasing complexity is the ever increasing gap between the beginning and the end of the formal part of engineering education. This gap is increasing as the frontiers of knowledge are steadily and relentlessly pushed back. It is no longer possible in the span of a student's undergraduate years to bring him to a large section of the frontier. The time will come, and indeed may already be here in some curricula, where it will be impossible for the average student to reach the frontier in his undergraduate study, depending upon his particular goals. The important fact is that engineering education, even the formal part of it, will continue to grow. If its function is the aiding of scholars in their search for the frontiers, whether the process takes four years or eight, there will be teachers stationed all along the

* Awarded First Prize in the ASEE Young Engineering Teachers Paper Contest of 1955.

way, from beginning to end, to inspire and guide the student.

Permits Differentiation

While all the teachers in a certain sense have the same function, the manner in which they carry this out is quite different owing to the immense variety of formal courses, scattered as they are across the whole gamut of engineering education. This permits differentiation according to special functions. For instance, there are many teachers who, figuratively speaking, work within shouting distance of the frontier. It is their responsibility to give the students a detailed knowledge of the neighboring front, what technical battles are currently being waged, what large problems remain untouched. They must help the students to equip themselves with the very special skills and techniques needed in order to become skillful technical warriors. To be ideally prepared as a teacher of such courses, each would have to have spent some time at the frontier, to have first hand knowledge of it. While teaching, close contact would still have to be maintained. If the teacher were teaching some form of engineering practice, design work for instance, the teacher in planning and carrying out his professional development as an educator would include such musts as industrial experience, consulting work, and registration as a professional engineer. A teacher whose courses prepared students for specialized research work might follow a slightly different path in striving for professional development as an educator. His program would probably include a doctorate in his specialty and continuing technical research of publishable quality. In both cases above, the whole purpose of their activities would be to equip themselves to be better teachers for the courses in the area of their concentration. Such teachers would need to give very little thought to refinements of teaching techniques because their students, being within sight of their respective goals, would usually be highly self-motivated.

If, as postulated above, certain teachers take specific steps to qualify themselves to be inspiring teachers of their students in the area of their concentration, would it be wise to expect them to leave the area of their concentration and shift mental gears several times a day in teaching freshman or sophomore courses? What is the responsibility of the teachers of students just embarking upon a program of engineering education? At this stage, the students will still have many choices to make, many alternate paths open to them. Their teacher must illuminate the way for some distance ahead, point out in a general way where the various paths lead and do so in a balanced and unbiased manner. The students must be given the chance to make intelligent decisions. Even if the specialists described above relished the opportunity to teach the more basic courses, they would probably find that they would not possess the optimum qualities for such activity.

Can any teacher reasonably be expected to elect this as an area of concentration? What special abilities should teachers of introductory courses have and in what way should they plan their professional development as teachers so as to be of maximum service to engineering education? In short, in what way should they specialize? What follows will be an attempt to justify the statement that the existence of teachers concentrating in these areas is reasonable and perhaps necessary and that these teachers could be described as diversification specialists.

Consider first of all what type of individual would want to confine his teaching activities to introductory and basic courses. It would be a man, and surely there must be many such men, whose major interest in engineering education is in the activity of teaching itself, a teacher who would enjoy teaching almost anything but who enjoys teaching engineering subjects most of all because his mind is interested and challenged by technical concepts and truths. Such a teacher would take pride in his strategic role in launching students upon engineering careers, he would sense the importance of his pivotal

position. He would know that his students are not near enough to their goals to be invigorated by the sound and smell of intellectual battle at the frontier and therefore they are not, on the average, highly self-motivated. This teacher would be more concerned than others with teaching methods, course organization, and pedagogical problems in general. If such a teacher is to guide and inspire students whose individual paths will go in many different directions, if he must illuminate the way for them, he must necessarily have a rather diversified background instead of a very narrow one, consisting of detailed information about one subject matter area. Such a teacher ideally would be a specialist in diversification. In that way he could best fulfill his particular role in engineering education. Just as the other specialized teachers had special ways of developing themselves to be highly successful teachers in their areas, so will the specialist in diversification. He would be doing educational research of a publishable quality in teaching methods, curriculum design and the like. He would be taking advanced fundamental course work in many areas. All this to make him a better teacher in his area. Unfortunately, the real need for men dedicating their lives to these fundamental areas has not been explicitly recognized as much as the need for advanced specialists. Therefore, it may be some time before recognition and advancement will follow as it should. The more traditional methods of development are less applicable in the case of the man who wishes to perfect the basic courses and needs a broad rather than a narrow background. When such specialists in diversification are encouraged, all of engineering education will certainly profit, for is it not true that some of our weakest teaching is done on the lower levels?

Growing Sentiment for Less Specialization

Of special current interest is the Interim Report of the Committee on Evaluation of Engineering Education. The authors of the report stress the growing sentiment for less specialization on the undergraduate level. The committee proposes a curriculum with a common stem and it explains that the term "common stem" does not imply identical courses but is a phrase intended to clarify the need for a "unity of understanding" by students in different curricula. The teachers best equipped to help students to develop this "unity of understanding" would be those who had experienced it. It seems more and more imperative that at the lower undergraduate level we have not highly concentrated specialists but specialists in diversification, men who have developed by crossing traditional departmental lines (sometimes grown to walls) and roamed far and wide, the better to guide students in their progress. Such men would be the living example of unity of understanding. It is conceivable that a limited number of men would form links between colleges of engineering and sciences, or even better, where unity of understanding is even more lacking, between colleges of engineering and liberal arts. A specialist in diversification would be able to speak the technical languages of both camps and act as liaison expert.

A number of articles published in the *Journal of the ASEE* have bearing in some way on the subject of this paper and are quoted below as a means of summarizing. The ASEE Committee on Recognition and Incentives for Good Teaching in a recently published article said: "The committee also recognized that teachers are employed to produce certain specified, desirable results. One of these is introducing students to a subject. Another is carrying them up to the intermediate stage. And still another is carrying them to the frontiers of knowledge in a subject. A teacher who is adept in producing one effect and performing one function with students may be quite ineffective if asked to produce other effects. A wise administration recognizes these differences and uses its teachers where they can be most effective" (1).

Thomas K. Sherwood, former Dean at M.I.T., had this to say regarding specialization in a department: "Though we would look a long time to find a man with all of the qualities on the list, it is not necessary that we find him, for many of the qualifications listed, though essential to the composite staff of a department, are not absolutely essential in each and every staff member" (2).

Regarding the background of the teacher of basis courses, Allen H. Blaisdell said: "In brief, since the bulk of engineering graduates will likely never receive more than four, or five at the most, years of college or university instruction it seems reasonable to suppose that such instruction should be placed in the hands of teachers who are not specialists, but men of general scientific knowledge, broad and sympathetic outlook, as well as sustained interest in the activities of the engineering profession. Possibly one might add that the less instruction the undergraduate student receives from pronounced specialists of any kind, the less unbalanced his basic education. . . . Common sense would seem to indicate that the highly trained and specialized scientist will not, of necessity, achieve spectacular results in his efforts to instruct undergraduates unless he is fortunate enough to lecture in the field of his specialty. When it happens that he is assigned to instructional duties of a more general nature, the specialist is placed at a disadvantage as compared with the teacher possessing broader background and more diversified experience in teaching" (3).

In another section of the Committee on Recognition and Incentives report the following is found: "The one important prerequisite for good teaching appears to be a growing mind. Whether that mind is growing as the result of a search for better teaching methods, for more knowledge, for better methods of applying knowledge, or for various other reasons is apparently not so important as the fact that the mind of the teacher is growing. . . . The question of teaching ability versus knowledge is one that must be solved by each university and each department in its own way. So much has been said upon both sides of this issue that the committee approaches this problem with great reluctance. Certainly no one would hire as a guide in frontier territory a person who had never been there. On the other hand, undergraduate education in engineering and science travels through fairly well explored regions, and many people who have never been to the frontier are completely familiar with these regions. These people serve not only as adequate but frequently as excellent and inspired guides." (1)

Conclusion

In conclusion, if the introductory undergraduate engineering courses are to be taught in the best possible manner, if engineering students are to achieve a "unity of understanding," it would seem that one of the best ways of doing this would be to recognize the need for teachers with diversified backgrounds and general interests, teachers with a great love for the activitiy of teaching itself, dedicated to the important task of launching students upon engineering careers in the best possible way. Such specialists in diversification are sorely needed.

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Professional Development of the Young Engineering Teacher*

By DONALD R. LAMB

Instructor of Civil Engineering, University of Wyoming

The problem of professional development in the Young Engineering Teacher is by necessity twofold. As was pointed out by the General Council of ASEE, the objectives set forth for the YET group included: "An understanding of the general goals and responsibilities of the two professions which every teacher of engineering follows: engineering and education," and "Guidance in his personal professional development both as an engineer and as a teacher." This bifurcation, however, converges into one single purpose: becoming a professional person.

"Whosoever shall compel thee to go one mile, go with him twain." This portion of the Sermon on the Mount adjures perfection. "Every avocation has its mile of compulsion, its daily drab tasks and duties, its standards of honest craftmanship, its code of man-to-man relations, which one must cover if he is to survive. Beyond that lies the mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the distinction of a profession" ("The Second Mile," William E. Wickenden, *Electrical Engineering,* May 1942). It is this second mile that concerns the YET today. With the excellence of education at the disposal of all, the first mile can be accomplished by most engineering graduates. Before one can start on the second mile a definition of profession as well as its qualities should be set forth. The dictionary conveys the idea that a profession is an occupation which requires a liberal, if not a specialized, education and involves mental rather than manual labor; that a profession implies scholarship as in the case of the learned professions of law, medicine and theology.

Since the three learned professions are generally cited as examples of what a profession is, service to society or ministry to the people is an important characteristic of a profession. A quote from Vannevar Bush on "The Qualities of a Profession" (*Electrical Engineering,* April 1939, pp. 156–160) will help exemplify this point. "In every one of the professional groups will be found the initial central theme intact—they minister to the people. Otherwise they no longer endure as professional groups.

". . . Ministry carries with it the ideas of dignity and authority; it connotes no weakness, and offers no apology. . . . There is no fog of subservience surrounding the concept. The physician who ministers to his client takes charge by right of superior specialized knowledge of a highly personal aspect of the affairs of the individual. The attorney assumes professional responsibility for guiding the legal acts of his client, and speaks with the whole authority of the statutes as a background. It is in this higher sense that we trace the thread of ministry to the people.

"This is the fuel which has kept alight through many ages the professional spirit.

* Awarded Second Prize in the ASEE Young Engineering Teachers Paper Contest of 1955.

Every time that the fuel has become exhausted, the light has gone out. It has not mattered how much was retained of trapping and mysticism nor what the profundity of utterance, there has been no true profession that has not with dignity and authority advised and counselled the people, that has not guarded the commonweal. For a true profession exists only as the people allow it to maintain its prerogatives by reason of confidence in its integrity and belief in its general beneficence."

A profession ministers to the people. Engineers minister to the people by their many contributions to the health, safety and convenience of the public. The engineering ministry is just as real, but it is usually applied in providing goods and services for people in the mass rather than personal service for an individual citizen. It is not surprising that the average citizen is more conscious of the "engineer" in the cab of the locomotive than he is of the engineer who designs the locomotive and the many other parts of a modern railroad system by which the citizen is enabled more quickly to accomplish his errand in comfort and safety.

Professional Development

The second mile, professional development, is accomplished in part by the individual and in part by his associates. The question "What can we do as individuals?" has been asked many times. If he sees a job that needs doing, and if he wants to have it done, and if he is willing to exert himself to help do it, then a person should start with himself and with those most closely associated with him in his own community. Each one should continually prepare himself for greater responsibilities and for greater opportunities. Each one should support work in the broader field of his professional interest by whatever mechanism is at hand or by joining with his fellows in the development of a mechanism appropriate to their local problems. Each one should be active in some local civic organization, thereby demonstrating to the people in other walks of life that engineers are not narrow, anti-social specialists.

A short digression is in order at this point. The first premise discussed was professional development. The discussion following this text has dealt with what a profession is supposed to be and how the professional man develops along these lines. Unless at this point it can be definitely said that the profession exists, the evolution of any other ideas becomes meaningless. The author feels that the engineer has a profession but if he does not work to preserve what has been accomplished and strive to add a stronger unity of purpose toward a singular goal, a union and not a profession will transpire.

The second mile now lies ahead. The signs that direct one onward are education and scholarship, research or consulting, complete cooperation with cohorts, participation in learned engineering groups and association with civic programs and ideals. This is the trail of voluntary effort where one can strive for excellence and invest his work for enduring significance.

Formal training is, of course, the prime requisite for entrance into engineering education. The master's degree should be the minimum effort of any person interested in teaching. If, in obtaining a doctor's degree, a person completely burns himself out, he will not be of value in the teaching field because of the lack of energy and individual excitement. Therefore, one will have to make a sacrifice of an advanced degree if it would impair his teaching effectiveness. The formal education that has been discussed ends usually with a degree, but as in other learned professions, engineering is marked by the continuance of study throughout one's entire career.

Scholarship, of course, is an important facet of education. Scholarship in all things is a very worthy goal. But there has to be a meeting point between scholarship and application. Vetruvius summarized this many years ago when he said

"Architects who have aimed at acquiring manual skill without scholarship have never been able to reach a position of authority to correspond to their pains. While those who relied only upon theories and scholarship were obviously hunting the shadows, not the substance. But those who have a thorough knowledge of both, like men armed at all points, have the sooner attained their object and carried authority with them."

The research and consulting signs are out for all to see. It is almost impossible to conceive of an individual who is exerting his energies in the direction of the second mile not being inquisitive. How any man can really teach science or engineering without acquiring a consuming curiosity about the many things that are unknown is unbelievable. And how one can get a glimpse of the unknown without an equally consuming desire to tell it to others who will carry it on is also a mystery. An inquiring mind must be the chief possession of the YET. And that's the only kind of a mind that can either explore the unknown or stimulate associates.

The aim of research is to advance human understanding. We believe in human understanding for its own sake. We believe humans differ from the beasts largely in their ability and their urge to learn, to know, to comprehend. And what good is understanding? Well, aside from the fact that we are unsatisfied without it, aside from the fact that intellectual achievement possesses beauty and elegance which is good for its own sake, understanding leads to advances in human welfare. It abolishes ignorance and fear. Science and engineering are the chief tools in man's eternal struggle to achieve his highest moral and spiritual ends.

Research for All

Even though the cry "I don't like research" has been heard from each section of the country, there is research for all. Research does not need to be highly technical but can be down-to-earth and uncomplicated. We need to have better design methods, better teaching techniques, and fundamental student-teacher problems examined. There is some beneficial type of research for each person along the second mile.

The consulting work a YET can do during the summer gives him a chance to apply the theories he teaches, with conviction, during the winter. The consulting work also gives him opportunity to view how other people apply the theories that were learned and are now used. One cannot discount the financial gain of this type of mental advancement, but consulting should be used for mental growth rather than financial advance. One cannot stand still, he either advances or he falls behind, and in our fast moving society it is extremely difficult to make up lost ground.

The most difficult portion of the second mile is complete cooperation among associates. "Very many people refer all their problems and perplexities of deportment to the Golden Rule: 'Do unto others as you would that they do unto you.' Generous and high-minded men have thought the question through and find the Golden Rule best suited to their outlooks and temperaments. Others are too busy (or too lazy) to think about the question at all. . . ." This quote was taken from "On Engineering Integrity" (Committee on the Promotion of Ethical Standards, ASEE, *Journal of Engineering Education,* Dec. 1953), and certainly points out that cooperation is a thought process first—action second. By following this lesson as well as the parable of the Good Samaritan, the unimportant things that transpire among men to breed jealousy would pass unnoticed. By helping others in the daily problems of teaching, research and scholarship, better cooperation would be established as well as dissemination of knowledge.

Each branch of engineering has its professional group. In these groups the technical information in each field is sent to each participating member. Active work in the founder societies has its rewards in not only making it possible to

keep up with the rapid advances in the field, but in giving an outlet for the productivity of the members. Association with professional people can transmit professionalism to those who are young and receptive.

All of the YETs should also belong to the one educational society, ASEE, of their profession. Not only are the problems and explanations of his age group reported and discussed, but also the great backlog of information and experiences of the not-so-young teachers. Let it be pointed out here that "belonging to" is not active participation in the professional groups. One can get out only as much as one puts in.

As a person settles down into the life of a community he has to become part of this group. To become part of a community one must participate in the affairs of state. It might be at this point that the real public relations part of the engineering profession should have its beginning. The other learned professions have their members in civil groups upholding civic ideals. In a church building program in a western city where a University was located, the building committee was composed of a cross-section of the parish. However, there was a conspicuous absence of engineers on the list, yet there was available at least one engineer from each of the departments in the engineering school.

If engineers are to prove that they are not narrow, anti-social specialists, they will have to become an important part of the community life and become associated with the civic ideals that are important to the life of their families and friends.

Conclusion

In conclusion, it should be pointed out again that the professional development of the young engineering teacher lies along the "second mile of voluntary effort, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance." To close, the lines of Matthew Arnold are a fitting exemplification of professional development: "Life consists not in getting and holding, but in being and becoming."

Lamme Award

The Committee on Lamme Award is always anxious to get nominations for the Award from the membership of the Society. Any member may place a name in nomination; the selection will be made by the Committee by letter ballot.

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to the art of teaching; contributions to research and technical literature; achievements which contribute to the advancement of the profession; and engineering administration. The Lamme Trust Fund was established in memory of Benjamin Garver Lamme. For a brochure describing the Award and a nomination form, please write to the Secretary, Professor W. Leighton Collins, University of Illinois, Urbana, Illinois.

Nominations should be sent to the Chairman of the Committee, Dean F. E. Terman, College of Engineering, Stanford University, Stanford, California by February 1, 1956. Nominations should be accompanied by evidence supporting statement and claims.

James H. McGraw Award for 1955—Presented to Frederick E. Dobbs

The *James H. McGraw Award in Technical Institute Education* is an annual award of $500 for outstanding contributions to this field of education. The award is administered by the Technical Institute Division of ASEE and is sponsored by the McGraw-Hill Book Company, Inc.

Citation

To FREDERICK E. DOBBS, distinguished teacher, educator, and administrator—for his outstanding contributions to technical institute education; for his stimulating leadership in the development of technical institute training facilities; for his administrative skill in guiding the destiny of Wentworth Institute through periods of both peace and war; for the enviable examples of curriculum development, instructional facilities, and sound supervision which have characterized his work in this country and abroad; for his superlative achievements for the Ford Foundation in the development of technical education in Pakistan; for his tireless efforts as the Ford Foundation consultant to the Government of India in the development of the small industries program—this sixth annual James H. McGraw Award in Technical Institute Education is presented.

Shown above are participants in the presentation ceremony at the annual banquet of ASEE at Penn State University. Left to right: Dean Eric A. Walker, recipient of the award Frederick E. Dobbs, Dean N. W. Dougherty, Prof. Maurice R. Graney.

Annual Report of the Engineering College Research Council 1954–55

Prepared by HAROLD K. WORK
Chairman

During the past year, the Engineering College Research Council has continued to work on the various problems facing engineering schools, doing sponsored research. The basic problem has been approached in various ways, which are detailed as follows:

Publications

A new edition of "Review of Current Research and Directory of Member Institutions" has been prepared and will be available early in July. This booklet should be valuable to all of our member institutions, to individual faculty members, and to sponsors who are trying to locate and evaluate institutions for handling their research. The Secretary of the ECRC, Mr. Renato Contini, has been responsible for this publication.

A committee under Eric A. Walker has been working on the preparation of a book on "Creativity in Research." They are using as source material a group of papers presented at various symposia and meetings sponsored by the ECRC. In addition, some special solicited papers may be included. The available material is now being evaluated by a publishing house.

The Committee on Relations with Federal Government Agencies under R. J. Woodrow has prepared a brochure entitled "Sponsored Research Administration." This is an excellent handbook, covering many problems of interest to the research administrator. It will be published and distributed to member institutions. Provision may also be made to make it available to others.

Relations with Federal Government Agencies

The Committee on Relations with Federal Government Agencies under R. J. Woodrow has continued to be one of our most important and active committees. The Committee has considered a variety of subjects and a brief resume of such activities will be given here.

Overhead and direct costs of research conducted for the Government are being studied by the committee. A problem exists, with the Department of Health, Education and Welfare and others, who do not want to cover the full cost of the research. The Committee will continue to press for a single standard of payment for research in which research costs are fully reimbursed above the lines of the Mills formula.

A regulation promulgated and distributed by the Department of Commerce which imposed severe limitations on engineering schools in the performance of their functions in education and research was the subject of considerable concern. Through the activities of the committee the regulations were redefined in such a way that it minimized the objectionable features as far as educational institutions were concerned.

Relations with Industrial Research Agencies

The Committee on Relations with Industrial Research Agencies under S. T. Carpenter continued to maintain relationships with those organizations most concerned with industrial research. These included the Research Committee of Na-

tional Association of Manufacturers and the Industrial Research Institute. An attempt was made to arrange a regional conference with NAM but this did not materialize.

As a part of the annual program, the committee arranged joint sessions with the Graduate Studies Division on subjects of interest to industrial research people as well as engineering research people.

Awards

At each ASEE Annual Meeting a series of awards is given for various educational activities but there is no award specifically aimed at the stimulation and improvement of engineering research. A Committee was set up under the chairmanship of R. J. Martin to determine whether or not such an award was desirable. This was decided in the affirmative and the committee is now trying to define the nature of the award and arrange for its financing. It is planned that such an award will be initiated in 1956.

Basic Research

The Committee on Basic Research, which was originally set up to help the National Science Foundation in its engineering research activities, has been discontinued as its services are no longer needed.

Research Administration

Many of the problems in the administration of sponsored research are not covered by our present committees. For example, the excellent salary analysis recently prepared by Virgil E. Neilly would fall in this category. It was decided, therefore, that a committee was needed on research administration which might study various problems in research, such as (1) Overhead costs, (2) security requirements and (3) extra salary payments for staff members engaged in classified research, etc. R. A. Morgen was appointed chairman of the Committee and selected as his first project, the study of how research personnel, in various research organizations, are handled in the matter of tenure, fringe benefits and so forth. The Committee is also considering a study of standardization of reports.

Program for the National Meeting

The program committee under the chairmanship of R. G. Folsom developed an interesting program. In order to be certain that people interested in both education and research would find something of interest in the program, the general session involved relationships between the two. Three eminent speakers, two of which are engineering school presidents and the third a corporation president, were secured.

Another joint dinner was arranged with the ECAC and Dr. E. W. Engstrom, Vice President of the Radio Corporation of America was the speaker.

Two joint, open sessions were arranged with the Graduate Studies Division. It is felt that the combination of our activities with those of other committees should be encouraged in the interest of converting small competing meetings into better joint meetings.

As is customary, a closed session was held at which the various problems of ECRC members were discussed on a more or less confidential basis.

Four executive committee meetings were held during the course of the year as well as numerous committee meetings.

Nominations

The Nominating Committee under the Chairmanship of Frank W. Dawson presented names to replace the following officers who are retiring:

R. A. Morgen
F. C. Lindvall
G. R. Town

Those nominated by the committee and elected by the ECRC representatives are as follows:

K. F. Wendt
T. J. Killian
H. W. Barlow

Report of the ASEE Committee on Atomic Energy Education

Prepared by PHILIP N. POWERS
Chairman

Purpose of Committee and Earlier Activities

The Committee was established in 1950 under the leadership of Thorndike Saville, President of ASEE at the time. Its purpose was to help engineering colleges to become better informed about the needs for engineers with training in nuclear energy and the availability of teaching materials. Close liaison with the AEC was provided at the outset, and regional subcommittees were formed to arrange for conferences.

Committee Meetings Since Last June

The Committee met in Ann Arbor immediately after the ASEE meeting in Urbana last June and again in Chicago in May. Most of the work has been performed by six different subcommittees.

Preparation of Reactor Engineering Textbook

In May of 1951 the Committee recognized the need for a nuclear engineering textbook and proposed to the Atomic Energy Commission that they arrange for its preparation and publication. The Commission acted favorably on this proposal, and Dr. Samuel Glasstone was engaged to prepare the text. Since then, a subcommittee under the chairmanship of Dean R. C. Ernst has reviewed Dr. Glasstone's work, and the final draft was accepted by the full Committee in May 1955 as meeting the objectives originally set. The Commission has now been informed of this action of the Committee and that we believe the book will be very useful in assisting engineering educators to incorporate nuclear materials into the engineering curriculum. The title is "Principles of Nuclear Reactor Engineering."

Conferences at the Penn State Meeting

Under the chairmanship of Professor Glenn Murphy, a subcommittee organized two conferences for the Penn State meeting. The first was on the objectives of atomic energy education and on the present extent of unclassified research in nuclear engineering.

A second conference was held in cooperation with the Relations with Industry Division. The theme was "Industry and Nuclear Engineering Education," and there were papers on the need for engineers with nuclear training, the role of the colleges, and the role of industry in providing the training.

Survey of Nuclear Engineering Research

Under the leadership of Professor Herbert S. Isbin, a survey has been made on the progress being made by our universities and colleges in furthering nuclear engineering research. The Commitee believes that encouragement should be given to educational institutions to increase their research activities in areas involving nuclear energy problems. It is hoped that the data which have been collected regarding present activities will be helpful to engineering colleges in planning their own programs.

Participation in the Nuclear Engineering and Science Congress at Cleveland

Last fall President Dougherty advised the Chairman of this Committee that he had attended a meeting called by the Engineers Joint Council to consider the pos-

sibility of a joint effort among several engineering societies to organize a Nuclear Engineering and Science Congress. He asked the Chairman of this Committee to serve as his representative in subsequent discussions of this problem. As a result, ASEE is one of the participating societies in the forthcoming Congress to be held in Cleveland this coming December. ASEE is taking responsibility for a half-day conference on nuclear education problems. Professor Cliff Beck of North Carolina State College serves as Chairman of the subcommittee which is making these arrangements. The program which we are planning will involve presentations by several outstanding engineers in the nuclear field on the educational requirements for work in the field.

Objectives and Materials for Atomic Energy Education

At its meeting in June of 1954, the Committee agreed that serious attention should be given to what the Committee could do to help in identifying educational objectives in atomic energy and to help engineering professors find out about unclassified materials which might be helpful to them. As a result, a subcommittee under the chairmanship of Dean George Hawkins wrote to 143 deans of engineering schools and asked them to choose among four different ways in which our Committee might help. The plans which he asked them to consider were:

1. Having an individual who is an authority in the field and who understands the problems of engineering education visit your institution to discuss atomic energy education with interested members of the faculty, and to suggest procedures that might be used.
2. Having a team composed of authorities visit your institution to discuss the problems with interested members of the faculty.
3. Having a report prepared and distributed describing various procedures that could be utilized in incorporating nuclear science into the engineering curricula.
4. Sending representatives of your faculty at your expense to regional conferences devoted to the subject.

He had a very fine response with some interest expressed in all four plans, but with a great majority preferring the third, in which a report would be prepared and made available to engineering faculties.

This response led the Committee to believe that it had been given an assignment which it should take very seriously indeed. The recent upsurgence of industrial interest in atomic energy work and the present unprecedented demand for people with competence in nuclear energy makes it clear that the training of the engineers needed has become a big and urgent task. It seems to us essential that the ASEE do what it can to meet the requests which we received and to serve the engineering colleges through helping them to decide how best to meet these demands at the undergraduate and graduate levels and in extension work. Because of the present urgency, the government is providing specialized nuclear training for engineers and scientists from abroad as well in this country, and it seems obvious that engineering colleges must carry an increasing share of this burden.

A Proposed Study of Educational Requirements

The Committee believes, therefore, that it should be authorized by the Society to make a comprehensive study of educational requirements in this field, and we have prepared a specific proposal for the consideration of the Council. The pattern which we have in mind resembles the study which was performed by the Committee on the Evaluation of Engineering Education. It will be necessary to ask some one member of the Committee to allow his office to be used for putting the materials together and the preparation of reports. Financing would have to be adequate to permit the Committee and necessary subcommittees to get together as required and to permit visits to engineering colleges. The plan was prepared by a subcommittee under the chairmanship of Professor Glenn Murphy, and he has agreed to present our plan to the Council.

Report of the ASEE Committee for Young Engineering Teachers

Prepared by PHILIP WEINBERG
National Chairman CYET, 1954–55

Introduction

This report is intended as a brief summary of the activities of the CYET. Included are a series of recommendations, the most significant being a proposal for establishment of a summer workshop for young engineering teachers.

Committee Activities

This year has seen an interesting growth in the committee's functions. Many sections which were relatively inactive in the past have developed many programs. A few formerly active sections showed a noticeable decline. The interesting feature here was that earlier programs had left a residue which kept institutional activity alive even though sectional coordination was lacking. Much depends on the sectional YET representative and the kind of cooperation he can obtain from institutions and sectional officers.

Typical of the activities this year were seminars, panels and conference meetings. Many of the annual section meetings have contained a session planned by and concerned with the YETs. Other activities ranged from dinner meetings for combined groups of administrators and YETs to the planning and financing of a 3-day conference for all young teachers in a section. On this latter statement, I might mention that the section in the past was quite inactive.

Recommendations

1. Officers for 1955–56

a. Professor John L. Artley—National Chairman, Duke University
b. Professor Thomas Boyle—National Vice-Chairman, University of Michigan
c. Professor Lee Harrisberger—Vice-Chairman for Sub-Sections, North Carolina State University

2. Appointment of Sub-Chairmen

It is the recommendation of the committee that sectional sub-chairmen be elected at sectional meetings by the general membership. The term of office to be left to the section but not to exceed two years. It is suggested that the term of office commence no later than the beginning of the school year following the election. Where this is inconvenient, the prerogative for time of taking office should be left to the section.

Reasons set forth for this recommendation are:

a. Closer cooperation is possible between section officers and YET subchairman
b. Increased status of YET representative
c. Procedure will be more democratic

3. Membership Drive

It is recommended that the CYET be delegated to assist the Society in its membership drive. Since an institutional representative is established, it provides the opportunity of a personal contact.

4. Paper Contest

It is recommended that the paper contest be continued. Notification of the

rules should be sent to all section chairmen and the chairman of CYET, by October 1, 1955, for early publicity. It is suggested that papers submitted be reviewed for possible publication value, and that this be publicized in the announcement of the paper contest. It is further recommended that one member of the national judging committee be a qualified YET.

5. Summer School on Educational Methods

It is recommended that a short term summer school be planned by the educational methods division and CYET to precede the convention on a theme stressing pedagogical matters.

6. Annual Summer Workshop for Young Engineering Teachers

It is recommended that a committee be appointed to study the feasibility of establishing an annual summer workshop for young engineering teachers. This recommendation is consistent with recommendation B, Section VIII of the Report of the Committee on Improvement of Engineering Teaching. There are strong indications that industry will support such a workshop financially. The proposal sent to certain prominent educators and responsible industry leaders was in essence as follows: With the impending shortage of teaching talent, there will be a tendency for the schools to meet their needs by the utilization of less qualified persons. I would propose the establishment of a summer school to be held annually for which, say 50, engineering teachers would be invited to participate. Educational theory and methods of teaching specific technical subject matter should be major factors of the curriculum. The only stipulation would be that each teacher take back to his institution the ideas that he had obtained by conducting regularly scheduled seminars and organized programs in which the exposition of the acquired knowledge could occur. Ideally, the staff of such a school would consist of those educational and industrial representatives who have gained well-established reputations and would be well qualified to make a contribution to the instructional facility.

Now as to the details of such a proposal, the mechanism might be an eight-week seminar session to be financed by educational institutions and industry. In very recent years, as you well know, there has been a renaissance with regard to industry's attitude toward education. Industry is now earnestly seeking ways to put education on a firm footing. I suggest that one contribution might be the proposal stated earlier. In a period of ten years (when the shortage of teachers might be severest) 500 teachers with this summer session experience would have diffused through the engineering schools to help maintain qualities of education which may decrease at an alarming rate as the staff shortage becomes pronounced.

The session might be held at the host ASEE institution following the National Meeting thus permitting these young people to participate in the meeting. Each invited teacher would receive a fellowship to compensate for lost income. While many people should be willing to receive the educational benefit without financial compensation, I believe it would be necessary to provide a stipend if qualified people are to be attracted.

To establish a talking point, suppose we consider the following pattern: (1) Host institution or camp site might provide housing and eating facilities at a nominal rate; (2) The institution sending the young teacher would provide the travel funds and in return receive the benefits of an organized seminar program; (3) Industry would provide funds for the stipend and expenses for maintaining the school. This might be accomplished by soliciting a grant from the approximately 100 major companies which have ASEE membership, or perhaps a single organization might underwrite the operation.

What are the advantages that may accrue from such a program? (1) It would tend to provide better teaching and, consequently, provide a better product for industry; (2) In ten years a diffusion of informed young people could only have a stimulating effect on engineering education; (3) It would bring to the institutions ideas that its own faculties may not have explored (through seminars and organized programs); (4) It would permit young teachers to exchange ideas among themselves. This would broaden the base of engineering education by the transfusion of such ideas.

I suggest the committee be composed of engineering administrators, industrial representatives, YETs, representatives from the graduate study and the educational methods division.

Specific items of cost have not been included in this report. However, it is estimated that $60,000 would be required to operate the school and provide fellowships. Mention has not been made of possible solicitation from Foundations. A committee appointed to study the complete problem can best determine the method of securing the financial support. Again, I would like to emphasize that a prepared proposal is very likely to receive favorable support from industry.

These recommendations were thoroughly discussed at two meetings of the CYET in which a past president and a number of deans gave enthusiastic approval.

We have an opportunity to pioneer in an area that has been sorely neglected, that of developing college teachers. Let us give this our earnest consideration.

James H. McGraw Award

The James H. McGraw Award in Technical Institute Education is an annual award of $500 for outstanding contributions to this field of education. The award is administered by the Technical Institute Division of the ASEE and is sponsored by the McGraw-Hill Book Company, Inc. The award is made at the annual banquet of the Technical Institute Division of the ASEE.

Nominations for the award should be sent to the Chairman of the Technical Institute Division, Karl O. Werwath, President, Milwaukee School of Engineering, Milwaukee, Wisconsin.

Candid Comments

It Won't Be Easy

By DAVE SAUNDERS
Consulting Editor

The ability to write so as to convey successfully information of any kind necessarily is based on a comprehensive knowledge of language. Technical writers and editors cannot be made simply by establishing a college curriculum designed to teach technical writing and editing, nor can they be made by teaching English at any level above high school.

An adequately comprehensive knowledge of language begins in the crib. The failure of parents and of teachers in the early school years to teach English renders ineffective any later program designed to produce technical writers and editors. This failure is part of a vicious circle which begins with the fact that today's parents and teachers are generally inarticulate.

It is entirely probable that colleges have not established curricula for technical editing and writing because of the poor material that sits in their classrooms. Students today approach higher learning with only a meager knowledge of English. This is a result of the fact that schools have abandoned the basic theory that all learning depends on language.

"Language" involves much more than the ability merely to read and write. It involves the ability to select the right words and put them together so that the meaning is clear and unmistakable.

Without adequate training in the use of language, no student can be taught to produce good technical writing or to be a good technical editor. Students at lower levels are not being taught how to read and write effectively. When they reach the college level, they have not learned how to express their thoughts or to understand the thoughts of others, most of whom are in the same boat on an intellectually barren sea.

Why have our schools abandoned the basic theory that all learning is ineffectual without an understanding of language? This abandonment is the inevitable result of the unrealistic theories on which is based the so-called "child centered" school. We now are paying the penalty for failure to recognize and insist upon the importance of teaching English first. By "teaching English" I mean really teaching it, not presenting the child with disconnected words which he is not able to assemble properly.

Ours is a literate nation, but it is not articulate. It is an age of cartoon booklets and mystery stories written by authors whose attacks on the English language bring on spine-chilling shudders far worse than those caused by the plots. These authors, remember, are products of the same schools from which it fondly is hoped that the demand for technical writers and editors can be met.

It has been suggested that the discipline of learning to write is too much to expect of our children. Why? When is a better time to learn to write than in the formative years? It is preposterous and insulting to suggest that our children today are of such low mental capacity that they must be coddled.

It has been suggested also that we can't expect grade or high school students to be saddled with homework. Why not?

The theory that homework is too much for the child is part of the idiotic theories of the child centered school. Nobody ever learned anything beyond the bare essentials by limiting his education to the hours spent in a classroom. Homework is the practice of what is learned in school. The practice that is so necessary to development of a skill cannot be done at the same time the fundamentals are being learned.

These suggestions came from individuals who have not learned that it is grammatically incorrect to follow the adjective "like" with a verb or to start a sentence with a conjunction. Of course, grammar alone is not enough to make a writer or editor. Without good grammar, however, language becomes sloppy; and sloppy writing hardly is the sort of writing on which the culture of our people should be recorded.

With an adequate background in the English language, the man who reaches college level will need no more than a suggestive course in technical writing and editing. This course would need to include instruction in the techniques of reproduction, photography, drawing, and other things pertinent to editorial work.

Colleges have not established adequate curricula in technical writing and editing, not because they consider these subjects unimportant, but because it is impossible to teach them to students whose knowledge of English is pitifully inadequate. You cannot teach these subjects to unprepared students any more than you can teach calculus to a man who has not had algebra.

It would be useless to try to teach technical writing and editing at college level until the lower schools begin to teach English. Students in the lower schools are not required to write enough nor to read enough. Practice in writing should be had at these levels so that when the student reaches college, he can devote his time to college work without having to learn the rudiments of his native tongue. College is not the place to teach basic English, but the place to adapt what the student already should have learned to his college and professional life.

Until something is done about the pitiful condition of English students in schools below college level, we are faced with a continuing shortage of technical writers and editors. In an age when we are confronted with gibberish from the radio, television, press, and publishing house, it is almost a forlorn hope to ask for a Renaissance. There is no indication of it on the intellectual horizon.

Vital Problems

By GREGORY M. DEXTER

Scarsdale, N. Y.

Having retired professionally as a consulting engineer, I am free to argue for a more vital program by the JOURNAL OF ENGINEERING EDUCATION. Too often an article in the JOURNAL impresses me as limited in application or hackneyed as compared with the problems that should be discussed. So here are some vital problems that merit discussion:

1. If progress is to be made in engineering education, freedom of discussion on debatable subjects must be granted. Where strong disagreement on a subject's treatment might arise, arrangements could be made to publish a reply simultaneously with the inciting paper. This method is preferable to arbitrary censorship. In any case, brief discussion later should be invited. If the paper is too long, publication of a condensed version should be offered.

2. A few technical schools and at least one large manufacturing company are

testing prospective engineers for vocational preferences, mentality, and personality to learn if they are fitted for engineering and if so what type. A list of schools doing so, cost, and results obtained would be a valuable paper for future engineers.

3. The United States for industrial as well as defensive reasons needs all the engineers it can get. Artificial barriers should not be allowed to handicap Jews and Negroes from getting the necessary education as engineers. To what extent have the barriers been eliminated? Special effort was needed in New York State and is presumably needed elsewhere.

4. Some of our state technical schools are obliged by law to take all applicants who graduate from high school, regardless of their capabilities. What is the mortality of the freshmen in those schools compared with schools with stiffer standards? How do results compare with schools using the College Board Tests where the score is 500?, 600?

5. The Society should carry in its journal protests of any censorship of teaching as it occurs. There have been several deplorable incidents in the last few years. The most recent was the barring by the University of Washington of an address by Dr. J. Robert Oppenheimer, certainly one of the leading world physicists. Are our future engineers to be educated only on pap or are they to be given the opportunity to hear the best the world has to offer?

The list above could be easily increased. It should serve however to show how the JOURNAL could be handled to serve a more vital function in engineering education.

Evaluation of Engineering Teaching Ability

By FRANCIS W. ROYS

Dean of Engineering, Worcester Polytechnic Institute, Worcester, Mass.

In the May 1955 issue of the JOURNAL OF ENGINEERING EDUCATION is an article entitled "Evaluation of Engineering Teaching Ability" and at the end of the article is an editorial remark saying "Comments on the subject are invited."

It is clear that the writer of the article has done enough thinking to convince himself of the futility of any specific scheme of evaluation by points, items, etc. and as the last two paragraphs plainly testify and I can sympathize with these conclusions for I have tried various schemes, plans, graphs, tables, etc. and always with the same unsatisfactory results.

The answer seems inevitable that the measure of success is in terms of the results. In other words, are the students, on the average able to demonstrate their proficiency in mastery of the purpose of the course when it is completed? If the answer is yes, then the teaching must be evaluated as successful.

But what about the purpose of the teaching? Is it training in skills or intellectual development? Is it indoctrination or education? A teacher may be excellent in one area and very poor in another.

How many teachers, so called, especially the more inexperienced, really stop to think just what they are trying to accomplish? It may be that mastery of a subject may depend mostly on pure memory, like learning the multiplication tables after the idea of successive addition is understood. It may be partly memory and partly association, accompanied in the higher realms by philosophical reflection as in History of various kinds. It may be memory of basic processes followed by logical analysis as in various kinds of mathematics. It may be appreciation and understanding of basic laws of natural sciences, or it may be philosophical generalizations based on

these laws or techniques in their use for the solution of practical problems.

It may be for training in craftmanship in any one of a thousand kinds.

Now, if the purpose of the effort is just to teach someone *how to do* certain things then a method of indoctrination is quite effective and fast but if understanding of why things are as they are and to what purpose or conditions they apply to, or what possibilities and limitations are involved then mental processes of consideration, comparison, analysis, deduction, conclusion, etc., etc. must be developed or *drawn out* and it requires special skills in *educational methods* possessed in high degree by relatively few so called engineering educators.

A man may know his subject; may be an excellent lecturer; may be a fine demonstrator and explainer and so do quite well on an indoctrination basis and yet an almost total failure in accomplishing development of a student's intellectual power in logical deductive analytical and philosophical thinking. In fact, he may be a very poor educator in the real sense of the word.

And so I repeat that if the students have grown under the teacher in real intellectual stature so that on the average they are able to demonstrate their proficiency in mastery of the real purpose of the course at its completion the teacher could well be evaluated as effective and successful.

Any teacher who is able to accomplish the real purpose of a course would, by necessity, have to keep himself up to date by activity in a fair proportion of the areas and interests discussed in Mr. Evans' article.

Good teachers become recognized by their students without any doubt although the attributes of one may be very different than those of another. In fact it is this variety which lends spice to an adequate and effective faculty and it probably is better that we shall be reasonably content with this recognition rather than with any precise evaluation of ability in Engineering Education.

In the News

Dr. J. Whitney Bunting, former president of Oglethorpe University, has joined the Educational Relations Services Department of the **General Electric Company** at New York City as consultant in educational research.

Minutes of the Executive Board

Pennsylvania State University
June 20 and 22, 1955

A meeting of the Executive Board of the American Society for Engineering Education was held at the Hetzel Union Building on June 20 and at the Nittany Lion Inn on June 20 and 22, 1955. Those present were N. W. Dougherty, *President;* W. L. Everitt, B. R. Teare, Jr., L. J. Lassalle, and H. K. Work, *Vice Presidents;* G. W. Farnham, *Treasurer;* W. Leighton Collins, *Secretary,* C. E. Watson, *Assistant Secretary and Editor;* Mrs. Naomi Garman, *Office Secretary;* E. S. Burdell, L. E. Grinter, J. F. D. Smith, *Guests.*

1. *Report of the Secretary*

The mimeographed report presented is attached as Appendix A.*

a. The Executive Board *VOTED* to continue Professor C. E. Watson as Editor until October 1, 1955.

b. Due to there being over 900 members delinquent in dues for one or more years it was agreed a letter from the Treasurer stressing the need for individual dues payment should accompany the next dues statement to these members.

c. The general status of the Society's activity in regard to the Nuclear Engineering and Science Congress to be held at Cleveland, Ohio on December 12–16 was briefly discussed.

d. The Executive Board *VOTED* to increase the salaries of Mrs. Naomi Garman and Mrs. Louise Chambliss $10 per month.

2. *Report of the Treasurer*

The mimeographed pro forma statement for the current year and the budget for next year is attached as Appendix B.

a. The *pro forma* statement replaces what was previously called the "preliminary audit." Outstanding bills or balances were not verified by the auditor in order to avoid duplication of effort and unnecessary expense. The cost of the furniture purchased was charged to current expenses instead of to reserve, as previously directed by the Executive Board, because current income adequately exceeded expenditures. The Executive Board approved both changes.

b. A proposed budget for 1955–56, last column of Appendix B, was submitted for discussion. It was requested that ECAC and ECRC study the amounts allocated and recommend desirable changes. It was understood this budget would need to be modified in accordance with the actions taken at current Executive Board and General Council meetings.

c. The Chairmen of ECAC and ECRC later reported that the proposed budgets for their activities were satisfactory, it being understood that income from the sale of ECRC publications be credited to their account. The Executive Board recommended approval of the budget to the General Council.

d. The Executive Board *VOTED* authorization to the Secretary for the purchase of window air conditioners for the Society's offices and a rug for the Secretary's office.

e. It was agreed to recommend to the General Council that members joining the Society after the first of each year have their membership and dues start at the beginning of the next fiscal year, but that they be placed on the mailing list as soon as dues are paid and informed that they can attend the Annual Meeting.

* Appendices are not presented here since most of them will be printed separately as reports of officers or committees.

3. *Report on ECAC Activities*

The mimeographed report presented is attached as Appendix C.

a. Vice President Everitt explained the progress of the work of ECAC in developing a plan for administering industrial fellowships. It was agreed the proposed method of administration and the acceptance of the check from the first sponsor be recommended to the General Council for approval.

4. *Report on ECRC Activities*

The mimeographed report presented is attached as Appendix D.

a. Vice President H. K. Work explained the desire of ECRC to solicit funds from the National Science Foundation to determine the research needs of the Engineering Sciences and how the needs shall be met. It is estimated that about $40,000 is needed for the two-year study. Engineers Joint Council indicated they will approve and actively support the study and later review the findings. The Committee in charge of the study is to be E. A. Walker, Ralph Morgen, and E. B. Stavely. The Executive Board *VOTED* to recommend favorable action to the General Council. A budget is to accompany the request to the Council. It was suggested a set of rules to be prepared to guide all new chairmen in procedures to follow in the solicitation of funds for ASEE projects.

b. The Executive Board Voted to authorize ECRC to raise $5000 for the establishment of an annual award for research, the award to be a medal. The first award is to be made in 1956, and if no fund has been established by then current ECRC funds will be used. If the award is to bear the name of some individual or company, approval of the Executive Board must be obtained.

5. *Report on General and Regional Activities*

The mimeographed report presented is attached as Appendix E.

6. *Report on Institutional Division Activities*

The mimeographed report presented is attached as Appendix F.

7. *Evaluation of Engineering Education*

a. Dean L. E. Grinter, Chairman of the Committee, read the letter to accompany submission of the final report on Evaluation of Engineering Education to the General Council. The Executive Board approved and commended Dean Grinter and his committee for their excellent work.

b. Funds on hand are adequate for printing needed copies of the report. It was agreed the selling price of reprints should be nominal, essentially the same as for the Interim Report.

c. Money remaining in the fund is not ear-marked and could be used to foster further contacts with industry. The Relations With Industry Division appropriately may wish to sponsor one or more meetings with representatives from industry to discuss the report.

8. *Humanistic-Social Research Project*

a. Dr. E. S. Burdell, Chairman of the Committee, reported that progress was much greater than expected. A tentative report is to be presented at the Tuesday General Session and the final report should be available for printing by midwinter. When the report is completed, it will be reviewed for comments by liberal arts and industrial advisors. It was estimated that about $9000 remained in the fund, sufficient for printing the report. It was agreed the final report should be published in the JOURNAL OF ENGINEERING EDUCATION in order that it be incorporated in the official records of the Society. It was further agreed the style of reprints available for sale need not be the same as the report on Evaluation of Engineering Education. The cost of reprints is to be determined later, but it was agreed it should be low to encourage both single and large lot purchases. Of particular importance was the enthusiastic reception

of the field workers and the "missionary work" they were able to perform.

Note: Item 28C was presented at this session but is reported under "Other Business."

Wednesday, June 22, 1955, 6:30 P.M.

In addition to all the officers listed for the meeting on June 20, M. M. Boring, W. T. Alexander, and F. C. Lindvall, *newly elected officers* were present.

9. *Graduate Study Project*

a. The status of the project was reviewed by President Dougherty. It was agreed the project should be financed by a single grant from a foundation rather than by requests to many industries and other organizations. President Dougherty is to convey this information to Professors N. A. Hall and E. Weber and discuss the project with them.

10. *Educational Aids*

The Secretary was requested to review past correspondence and minutes to determine the correctness of placing the income from the sale of Educational Aids in the general fund of the Society.

11. *Annual Meeting Guide*

Professor John C. Reed reported by letter that in accordance with instructions from the Secretary he had completed the preparation of the Guide and was submitting 100 mimeographed copies with the recommendation that they be used. The report was accepted and the Executive Board *VOTED* to give Professor Reed $25 with which to purchase a gift for his secretary. It was agreed not to make further changes or additions until the local committees at Iowa State and Cornell and Professor K. L. Holderman had the opportunity to use and review the guide.

12. *Summer Institute Program*

a. Plans for the Summer Institute on Theoretical Engineering were deferred pending conferences with representatives of the National Science Foundation.

13. *Lamme Committee*

The report was accepted and submitted to the retiring president for consideration in appointing new members of the committee.

14. *Summer Schools for 1956*

It was recommended the requests be submitted to the General Council for approval.

15. *Summer School for YETs*

President Boring presented a proposal that each year the host institution of the Annual Meeting sponsor a six-week summer school for about 50 selected YETs. The general objective of the program would be good teaching and the development of good teachers. Each YET attending would receive $600–800 and his institution would pay the necessary travel expenses. The estimated $50,000 required to operate each summer school would be raised from industry.

16. *Book of Collected Papers on Engineering Education*

It was agreed the preparation of such a book was not within the scope of the work of the Society.

17. *San Francisco International Science Center*

It was agreed no information would be submitted until more information became available.

18. *Evaluation of Dutch Engineering Education*

It was agreed the matter should be referred to EUSEC, and President Boring will reply.

19. *AAAS Meeting in Atlanta*

No action was taken on the proposal to hold the meeting elsewhere.

20. *AAAS Science Teaching Emergency*

The program was announced for information only.

21. *ASEE Editorial Committee*

It was agreed no appointments should be made until after the new Editor is appointed.

22. *Committee on Society Functions*

a. Dean B. R. Teare, Jr., Chairman of the Committee presented some of the proposals being considered for improving the Society organization and functioning. The Executive Board *VOTED* to allocate $800 to $1000 to the Committee for holding a two-day meeting to complete their study and prepare a report.

b. It was agreed to recommend to the General Council that the name of the Upper New York Section be changed to the Upper New York-Ontario Section, provided a written request from Toronto University (and/or) Queens University is received.

23. *Printing Costs*

George W. Farnham, Chairman of the Committee, reported that lithographing the YEARBOOK would result in no economy the first year and some thereafter but not enough to warrant a change at this time. The study of the cost of printing the JOURNAL in the South is underway. It was agreed the study should continue and results presented at a later meeting.

24. *Institutional Membership*

a. Associate—The Executive Board elected Frederick Post and Company to Associate Institutional Membership.

b. Active—The Executive Board elected Ohio Northern University to Active Institutional Membership, subject to election by ECAC and ECRC to participate in their activities.

25. *Bank Resolutions*

Not presented.

26. *Future Annual Meetings*

The locations and dates for the next two years were reviewed. They are as follows:

Iowa State College....June 25–29, 1956
L. O. Stewart, General Chairman
Cornell University....June 17–21, 1957
J. C. Gebhard, General Chairman

27. *Next Meeting of Executive Board*

It was agreed the next meeting of the Executive Board would be at the new headquarters of the Society, University of Illinois, Urbana, Illinois, September 10, 1955.

28. *Other Business*

a. It was agreed the report on Degree Designations be presented to the General Council.

b. The Executive Board *VOTED* that the President appoint two members to serve on a joint EJC–ASEE–ECPD committee to plan the annual meeting of the Engineers Joint Council. It is to be held in late January of 1956 and the theme is to be Technical Institutes. The Society assumes no financial obligation.

c. The Executive Board *VOTED* to grant Dean W. L. Everitt, Secretary W. Leighton Collins, and President M. M. Boring authority to employ an Editor for the JOURNAL OF ENGINEERING EDUCATION.

d. W. Leighton Collins was reappointed Secretary for the year 1955–56.

e. Dean J. F. D. Smith, Chairman of the Relations With Industry Division, presented the request received for immediate action relative to RWI and ASEE participation in the IAESTE program for bringing students from Western Europe to this country to work in industry for short periods of time. The degree of enthusiasm for the project varies greatly. It was agreed Dean Smith should confer with Dean F. M. Dawson to determine the extent of the work of the International Relations Committee of ECAC and to confer with the ECAC Executive Board.

Respectfully submitted,
W. LEIGHTON COLLINS,
Secretary

Minutes of the General Council Meeting

Pennsylvania State University
June 20 and 24, 1955

A meeting of the General Council of the American Society for Engineering Education was held in the Parrot Room of the Nittany Lion Inn on June 20 and 24, 1955. Those present on June 20 were:

E. E. Ambrosius
H. H. Armsby
George F. Branigan
G. P. Brewington
C. A. Brown
F. L. Carnahan
W. L. Collins
Glen N. Cox
H. O. Croft
N. W. Dougherty
M. A. Durland
W. L. Everitt
George Farnham
Harold Flinsch
L. E. Grinter
F. Groseclose
Henry Hartig
S. C. Hollister
Howard K. Justice
Frank Kerekes
L. J. Lassalle
G. B. Lobingier
George A. Marston
Glenn Murphy
Bert H. Norem
Ralph Paffenbarger
H. P. Rodes
Thorndike Saville
Rex Schoonover
John W. Shirley
P. E. Soneson
E. B. Stavely
L. E. Stout
B. R. Teare, Jr.
N. D. Thomas
Robert Van Houten
R. E. Vivian
E. R. Wilcox
W. R. Woolrich
H. K. Work

Those present on June 24 were:

Alexander, W. T.
Ambrosius, E. E.
Armsby, Henry H.
Dougherty, N. W.
Borg, Grant H.
Boring, M. M.
Branigan, Geo. F.
Brewington, G. P.
Brown, C. A.
Collins, W. L.
Christensen, N. A.
Donovan, E. T.
Dougherty, N. W.
Durland, M. A.
Everitt, W. L.
Farnham, G. W.
Flinsch, Harold
Frush, C. O.
Grinter, L. E.
Groseclose, F.
Hellwarth, A. R.
Jackson, J. L.
Jones, C. S.
Kerekes, Frank
Lassalle, Leo Jos.
Marston, G. A.
Morgen, R. A.
Murphy, Glenn
McNair, Arthur J.
Paffenbarger, Ralph S.
Parker, N. A.
Peery, David J.
Richardson, L. A.
Rodes, H. P.
Saville, Thorndike

Schaffner, C. E.
Schoonover, Rex
Seeger, R. J.
Shackleton, S. Paul
Shirley, John W.
Stavely, E. B.
Stillman, Donald G.
Stout, L. E.
Teare, B. R., Jr.
Thomas, Neil D.
Van Houten, R. W.
Vivian, R. E.
Wilcox, E. R.
Wohlford, J. G.
Work, H. K.
Weinberg, Philip

1. *Report of the Secretary*

A copy of the report submitted to the Executive Board and made a part of its minutes of June 20 and 22, 1955 was distributed to all present.

a. The moving of the Society office to the University of Illinois and the arrangements with the University of Illinois were briefly presented.

b. In accordance with Yearbook figures for 1954 and 1955, Individual Memberships have increased from 7095 to 7560. Of the 7560, 917 have not paid dues for the current year despite receiving three dues notices. During the year 250 members resigned and 42 died. Institutional Memberships were not actively pushed during the year, but according to the Yearbook the number increased from 96 to 112; two organizations dropped their membership during the year.

c. The Council *VOTED* to approve the 54 applicants for individual membership on List No. 1, attached as Appendix A.*

d. The Council *VOTED* to grant life membership to 16 members of the Society who met all the constitutional requirements for life membership. The names are on page 5 of Appendix B.

e. The Council *VOTED* to drop from membership 99 members owing more than two years dues. The list is attached as Appendix B.

2. *Report of the Treasurer*

A copy of the report submitted to the Executive Board and made a part of its minutes of June 20 and 22, 1955 was distributed to all present.

a. Treasurer G. W. Farnham submitted the pro forma statement instead of the previously used preliminary audit and explained the reasons for the change. The Council *VOTED* to approve the change and have just one audit made at the end of the year by an established firm of accountants. The audit will be published in the Journal. The *pro forma* statement is included in the minutes of the Executive Board Meeting for June 20 and 22, 1955. It was further suggested that consideration be given to the separation of project funds from Society funds so that the audit indicates the true condition of the Society finances.

b. A budget for 1955–56 was submitted for approval. There were no significant departures from last year other than the addition of items necessitated by moving the Society offices to the University of Illinois. It was understood that the proposed budget did not include expenditures approved during the current meetings. The Council *VOTED* to approve the budget. The proposed budget for 1955–56, the budget for 1954–55, and the *pro forma* income and expense statement are attached as Appendix C.

3. *Evaluation of Engineering Education*

a. Dean L. E. Grinter, Chairman of the Committee, read a letter submitting the final report to the Council for approval and requesting the discharge of the Committee. He also recommended that (1) Any reasonable number of the reports be purchased for distribution to industry and (2) Any funds left over be made available to the Relations With Industry Division for holding one or more conferences between educators and industrial representatives to acquaint everyone with

* Appendices are not presented here since most of them will be printed separately as reports of officers or committees.

the objectives of the report; members of the Committee would be available for participation in the discussions.

The Council *VOTED* to accept the report and that in conjunction with the acceptance, the Society expresses to the Chairman, L. E. Grinter, and to the Secretary, D. H. Pletta, and to the other members of the Committee its gratitude and appreciation for the patience, good judgment and enormous amount of work done in carrying to completion a most difficult assignment.

The Council *VOTED* that the Executive Board be empowered to use the balance in the fund (approximately $5000) to further the aims of the report, particularly as they pertain to the two recommendations made by the Chairman.

b. The opinion was expressed that reprints of the report be sold at a nominal price with a considerable reduction for large quantity orders, just as was done with the Interim Report.

4. *Humanistic-Social Research Project*

a. Dr. E. S. Burdell, Chairman of the Committee, and Dr. G. A. Gullette, Director of the Project, reported that the work had progressed so rapidly that a preliminary report was to be presented at the Tuesday General Session.

b. The final report will be available by midwinter. It was requested that after the report is published members of the committee be authorized to attend Section meetings to discuss the report and in that way spend the remaining funds credited to the project. The request was not granted; instead, the committee was asked to report at the October meeting of the Council and present plans for the publication of the report and for the visits to Sections.

5. *Educational Aids*

a. In accordance with the recommendations of C. W. Muhlenbruch, contained in a letter to the Secretary, the Council *VOTED* to discharge the Committee, but agreed to appoint a new one when demand and interest indicated a revision or a need for expansion into other fields of engineering. The Council commends Mr. Muhlenbruch for the great amount of time he devoted to the project and thanks him, and those on the Committee, for their fine work.

b. The balance of approximately $2000 in the fund is to be held intact for future use of a similar nature and for reprinting the current booklet. It was agreed the Executive Board should study the basis for the contributions from industry to determine the correctness of placing the income from the sales of the booklet into the general fund of the Society, as is done with income from the sale of all other publications.

6. *Graduate Study Project*

a. N. A. Christensen, Chairman of the Committee, submitted a written report, a copy of which is attached hereto as Appendix D. The activities of the Committee at the Annual Meeting and its future plans were outlined. President Dougherty also reviewed the past relations with the Executive Board. Proposals for financing, and the duplication of effort with ECAC's program for Industrial Fellowships were discussed. It was agreed the Graduate Study Division invite the ECAC committee to join it in the study of their mutual problem.

b. The estimated cost of the project is $15,000. The fund is to be expended for travel to two meetings each year and for printing of the report. Five subcommittees are to study the five specific topics. A detailed budget was not submitted, but was requested. The Council approved the study in principle and *VOTED* to refer the entire matter to the Executive Board with power to act.

7. *Summer Institute Program*

a. The Secretary reported that plans were progressing for the publication of the reports for all Summer Institutes sponsored jointly by NSF and ASEE. The reports of the closed conferences on

Mechanics, Electricity and Magnetism, and Thermodynamics have been published in the JOURNAL OF ENGINEERING EDUCATION. It must be recognized that all these institutes were jointly sponsored by NSF and ASEE and that NSF financed all of the closed conferences.

b. The conferences on Theoretical Engineering were not discussed at a General Session because of the need for additional joint planning with NSF.

8. *Resolutions to Officers, Divisions, Committees, and Schools Responsible for ASEE Summer Schools and Conferences*

The Council *VOTED* that the Secretary write a letter of appreciation to the officers of the divisions and committees and schools responsible for the 1955 Summer Schools and Conference.

9. *Report of ECAC Activities*

Copies of the report submitted to the Executive Board and made a part of its minutes of June 20 and 22, 1955 were distributed to all present.

Dean W. L. Everitt, Vice President and Chairman of ECAC, presented the plans developed for administering the three industrial fellowships offered by Leeds and Northrup, one each in Electrical, Mechanical, and Chemical Engineering. The plan proposed for a trial operation was for the Committee to select schools offering the Ph.D. degree and send each a letter asking if they would be interested in having a fellowship. The committee would then determine, by "scientific selection by random number" which school would receive the fellowship. In this way the concentration of fellowships at a few large institutions would be avoided. The Council was requested to authorize ECAC to (a) Accept $3000 from Leeds and Northrup for an initial award for 1956, $6000 for two fellowships in 1957, and $9000 for three in 1958; and (b) Select schools the students could attend and to select from among them, by random number, the school to receive the grant.

In the lengthy discussion which followed, it was brought out that last year's Executive Board authorized Dean Everitt to proceed with the negotiations and develop a plan. The plan was developed and presented to the Council in detail. Doubt was expressed about this being an appropriate area of endeavor for ASEE; constitutional and legal aspects to the question were raised: The Council *VOTED* that the President appoint an ad hoc committee to make a further study of the problem and present it to the Council at its next meeting, the study to include fellowship problems besetting institutions. Dean Everitt was instructed to request the courtesy of holding the check for $3000 until the Council comes to a firm decision.

10. *Report of ECRC Activities*

Copies of the report submitted to the Executive Board and made a part of its minutes of June 20 and 22, 1955 were distributed to all present.

Dr. H. K. Work, Vice President and Chairman of ECRC, stated the *Review of Current Research* would be available in July and that the book on "Creativity In Research" is progressing. Also, the committee on Research Administration is making a study of overhead costs, how research personnel are handled with respect to tenure, etc.

The desirability of establishing an ECRC award, consisting of a gold medal, for outstanding research was presented. It was proposed that outside funds be obtained, but if none were available in time for the 1956 award, the needed money was to come from the ECRC reserve. The Council *VOTED* to approve the establishment of such an award.

Dr. Work presented the recommendation of the Executive Board that, "Funds be solicited from the National Science Foundation to determine the research needs of the Engineering Sciences and how the needs shall be met." About $40,000 is needed for the two-year study which is to be an ASEE project directed by

the personnel of ECRC. The proposed budget is attached hereto as Appendix E.

11. *Report of Divisions and Committees*

a. *Ethics.* Dean C. J. Freund, Chairman of the Committee, reported that work is progressing toward a future preparation of a manual which would be in the nature of a case book illustrating the Canons of Ethics. A written report was submitted and a copy is attached as Appendix F.

b. *YET.* Professor P. Weinburg, Chairman of the Committee submitted a written report, a copy of which is submitted as Appendix G. In the discussion it was agreed the YETs will again conduct a membership campaign, including physicists as well as other groups not falling into the engineering curricula category, but which are involved in the teaching of engineers and which are represented in ASEE. It was further agreed the President should aid the YETs by extending a personal letter of invitation to join.

The Council *VOTED* to implement Recommendation No. 5 of the Report by authorizing the President to appoint a committee to study the question of having summer schools, planned by the Educational Methods Division and CYET, preceding the Annual Meetings and having a theme stressing pedogogical matters.

c. *Atomic Energy Education.* Chairman P. N. Powers submitted a written report attached hereto as Appendix H. Mr. Powers requested that his committee be authorized to make a comprehensive study to follow the pattern of Evaluation of Engineering Education. Finances would need to be adequate to permit the committee and the necessary sub-committees to meet as required and to permit visits to engineering colleges. The general areas of study would be:

(1) Immediate and future requirements for men with training in the nuclear field.
(2) Undergraduate, graduate, and special programs to aid in the development of engineers in the nuclear field.
(3) The part colleges and universities should play.
(4) The long-term role of training programs in Government Laboratories such as Argonne and Oak Ridge.

The study group would cooperate with other agencies such as the Atomic Energy Commission, colleges and universities offering programs in nuclear engineering, industrial organizations, EJC, etc. The estimated budget is $20,000. The Council *VOTED* to endorse the proposed study, authorize the committee to proceed with its plans, and authorize the Society to lend its support to the procuring of funds.

d. *Honorary Membership.* No report.

e. *Constitution and By-Laws.* Chairman H. O. Croft presented a written report to all present outlining changes in Article II, Section 2, 3, 5, and 6. The report is attached hereto as Appendix I. The Council *VOTED* unanimously to approve the changes as contained in the report. It was agreed the changes be submitted immediately for ECAC and ECRC approval.

The Committee recommended no changes in regard to:

(1) Article IX, Section 3. "Papers and discussions presented before Sections or Branches shall be the property of the Society . . . ."
(2) Article II, Section 4. "A member in good standing may become a life member, . . . by a single payment of an amount equal to twenty times the annual dues for members. Such payments . . . shall be placed in a separate fund known as the Life Membership Fund. . . ."

The Council *VOTED* to appoint an *ad hoc* committee to study the problem of ownership of papers as stated in (1) above and report to the Council at its next meeting.

f. *Society Functions.* The Council *VOTED* approval of the Executive Board's recommendation that the name

and boundaries of the Upper New York Section be changed to Upper New York-Ontario Section so as to include the University of Toronto and Queen's University.

Dean B. R. Teare, Jr., Chairman of the Committee, outlined some of the questions being considered by his committee and stated he hoped agreements could be reached at a special two-day meeting to be held during the Summer. The Council *VOTED* approval to the addition of $1000 to the budget to finance the special meeting.

g. *Technical Institute Division.* C. J. Jones, Chairman of the Division, presented the need for a book telling of the work of the technical institute and the place of its graduates in industry. A. L. Williston wishes to make an initial gift to the Society of securities, valued at $6000 but to be sold by the Society, for defraying expenses involved in preparing the book. It was further suggested that a committee be appointed to prepare the book, that the Society administer the funds in a manner similar to that followed for other projects, and that the copyright be in the name of the Society. The Council *VOTED* to approve the appointment of a committee by the President, to accept the securities presented for conversion to cash, and that the committee be reimbursed for its expenses in accordance with the established practice of the Society.

h. *Degree Designations.* In the absence of the Chairman, H. P. Rhodes read the report. Since the portions dealing with Honorary Doctorates and Associate degrees for Technical Institutes were not clear, the Council *VOTED* to receive the report and refer it back to the Committee for clarification and resubmission to the Council at its next meeting.

i. *Financial Policy.* Dean W. R. Woolrich, Chairman of the Committee, submitted a written report, a copy being attached hereto as Appendix J. The Council *VOTED* that the report be filed.

12. *Annual Meeting Guide*

The Secretary reported that Professor J. C. Reed had submitted 100 mimeographed copies and that copies were being made available to Annual Committee members at Iowa State and Cornell.

13. *EJC Constitution Changes*

The Executive Board recommended to the Council that the changes be approved. The Council *VOTED* to approve the amendments as previously passed by other constituent societies.

14. *ECPD Membership for NSPE*

There seemed to be some confusion regarding ASEE action. Since a committee is now studying the problem of enlarging ECPD, it was agreed the Council should await the report of the committee.

After this action President Dougherty reviewed past minutes of the Executive Board and reported on June 24 that a resolution was passed recommending extending an invitation to NSPE providing necessary approval was met, meaning that the invitation was not to be extended unless approved by the various Societies which are members. The Council *VOTED* to concur in the recommendation of the Executive Board.

15. *Future Annual Meetings*

The Secretary reported the following location and dates for future Annual Meetings:

1956 Iowa State.....June 25–29
1957 Cornell.....June 17–21

16. *Other Business*

a. *Report on General and Regional Activities.* Vice President B. R. Teare, Jr., briefly reported and stated the general position of the Sections was good, but that there was a real need for continuity of programming between Section Meetings and the Annual Meetings. Copies of his report to the Executive Board, and attached to its minutes of June 20, 1955 as an Appendix, were distributed to all present.

b. *Report on Instructional Division Activities.* Vice President L. J. Lassalle dis-

tributed copies of his report to the Executive Board, and attached the minutes of June 20, 1955, as an Appendix, to all present.

c. *AAAS Science Teaching Emergency Program.* J. A. Behnke, Associate Administrative Secretary of AAAS made an appeal for help in recruiting teachers for high schools, because better teaching of science and mathematics there directly influences the work of colleges of engineering. Of particular interest is the group of students dropping out of engineering and entering some other area of study. The 7-point program for improving science teaching was briefly outlined and a plea was made for suggestions and help in making their 3-year plan effective. The Carnegie Foundation is contributing $300,000 to put the program into effect.

d. *Summer Schools for 1956.* The Council *VOTED* to approve the requests for Summer Schools received from:

Mechanics Division
Humanistic-Social Division
Engineering Drawing Division
Civil Engineering Division

Approval of the host institution, Iowa State College is also a requirement for the holding of a Summer School.

e. Professor A. J. McNair, Chairman of the Civil Engineering Division, requested approval of a joint membership committee for purposes of certification of Sanitary Engineers in cooperation with:

American Society of Civil Engineers
(The sponsoring and financing organization)
American Public Health Association
American Water Works Association
Federation of Sewage and Industrial Wastes Association.

The Council *VOTED* authority to the President to appoint one to three members to the committee.

f. *Henry S. Jacoby.* President Dougherty stated Henry S. Jacoby, our oldest living past president, was one hundred years old. The Council *VOTED* that the Secretary send him a telegram of congratulations and extend the best wishes of the Society.

g. *Resolutions.* Dr. H. H. Armsby, Chairman of the Resolutions Committee, submitted a copy of the resolution presented at the Annual Banquet. A copy is attached as Appendix K.

17. *Next Meeting*

The Council *VOTED* that the next meeting be with the meeting of the Association of Land Grant Colleges and Universities being held at Michigan State on November 15, 16, and 17. The Secretary is to work out the details of time and place.

18. The meeting finally adjourned.

Respectfully submitted,
W. LEIGHTON COLLINS,
Secretary

Marquette College-Industry Conference

A College-Industry Conference will be held at Marquette University, January 25 and 26 to help celebrate the 75th anniversary of Marquette University. The theme of the meeting will be "The Humanistic-Social Approach as an Aid to Engineering."

• • • YET-ITUDES*

• *yelps and helps for the young engineering teacher*

Contributed by CYET
JOHN L. ARTLEY, *Chairman*
Duke University

Editor of YET-itudes
LEE HARRISBERGER
N. C. State College

A Higher Degree YET!

By MERL BAKER

Professor of Mechanical Engineering, University of Kentucky

The young teacher in engineering may ponder the potential value that a *thirty minute* reading knowledge of German or French would be to his class room teaching. The value of advanced mathematics in teaching an elementary course in heat power or theoretical physics for machine design may seem ridiculous. Some reason that the requirements of the Ph.D. are predominantly research and hours of midnight work, and that the training contributes little to a person's ability to teach undergraduate classes. It is true that some individuals have "died from the shoulders up" after receiving the Ph.D. and it becomes void of intellectual integrity and serves only as an asset to stimulate undeserved promotions and recognitions. Obviously, these individuals do not use the degree to the advantage of their students.

When or if a clear understanding of how a student learns is gained, the teacher becomes immediately aware of the fact that teaching is far more than lecturing, grading papers and giving examinations. The teacher must participate in some type of personal creative activity if he is to motivate his students, which might be writing, research, counselling, curriculum improvement, or committee activities. The pursuance of advanced degrees, especially the Ph.D., affords an excellent opportunity for individual creativity and for this reason, work associated with earning the degree will contribute immeasurably to good teaching.

Some younger teachers are discouraged from seeking advanced degrees because of the "decaying sap" progressively observed in some holders of the degree; others feel that they had rather "hear themselves lecture" than to be exposed to (and indoctrinated with) the thoughts of someone else (the skeptic), while probably by far the larger portion appreciate the value of the degree and are capable of earning it, but do not have the *financial* resources for pursuance (the realist). This obstacle can be minimized.

The July 1955 Quarterly Report of the Carnegie Corporation has an excellent report entitled "Wanted: Teachers

* "YET-itudes" is devoted to informing the Society of the needs, pleads, and deeds of the young engineering teacher. The potential of ASEE lies with the young engineering teacher. The CYET feels you should be informed of how much "fire is in the furnace."

YET-itudes! Not Platitudes!

and Scholars." It is one thing to teach and another to teach *well*. This report discusses the Woodrow Wilson Fellowship Program in the humanities and social sciences. Fellowships are provided on a competitive basis for B.S. graduates desiring to follow teaching as a profession. The program is supported by contributions from graduate schools and foundations.

Why not an effective fellowship plan for our young engineering teachers? There is much evidence to support such a plan as an effective way to improve the quality of engineering education.

Who should support the program financially? As *industry* profits most from well qualified engineering graduates, its support of a fellowship program would seem to be a good investment and not merely a contribution. The employer institution should consider its gain by supplementing the individual's stipend through leaves of absence with part pay. In addition such a plan should fit into the program of educational foundations. Does the young engineering teacher have time to pursue advanced degrees if he were awarded a fellowship? By working full time on the degree, the time required will be greatly reduced over that required were he to earn a living, allowing him to return to his job in a reasonable time.

An active program to assist our many capable young engineering teachers to pursue graduate work, should pay rich dividends in retaining an adequate number of teachers in the engineering schools in addition to improving the quality of teaching. The program must be initiated on a local basis by individual institutions or collectively by ASEE. Educational programs initiated and supported by a particular industry for its employees would not meet the need. Too many young teachers would fail to return to the class room after "grazing on the green pastures of industry."

Let's seek better future engineering graduates by helping our teachers now.

* * *

Here is your November YET-itude: It takes one to train one.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

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Is Engineering Graphics a Science?

By MATTHEW McNEARY

Professor of Engineering Graphics, University of Maine

In the January, 1955, issue of the *Journal of Engineering Education,* an article appears entitled "ECPD Accreditation of Fringe Curricula" which contains more than the title suggests. Included in this article are rather specific recommendations for the accreditation of "major" curricula. There is no mention in these recommendations of the expected role of engineering graphics (or engineering drawing, if you prefer) in the curriculum of the future. If we are to educate only pure scientists this omission is understandable, though regrettable. If, however, we are to educate engineers the situation may be much more serious. To remedy this, I suggest that engineering graphics be listed by the ECPD as one of the engineering sciences basic to engineering education.

Let us examine the requirements recommended by the ECPD for accreditation of "major" curricula. Summarizing very briefly, and taking some small liberties with the text, a "major" curriculum shall be recommended for accreditation when it meets the following criteria:

1. *One year* devoted to mathematics and *basic sciences,* equally divided.
2. *One year* devoted to *engineering sciences,* including at least six of the following: statics; dynamics; strength of materials; fluid flow; heat flow; thermodynamics; electrical circuits, fields, and electronics; engineering materials; physical metallurgy.
3. *One-half year* devoted to engineering analysis, design and engineering systems.
4. An appropriate portion (*usually about three-fourths of a year*) devoted to humanistic and social studies.

Adding up the years required for the foregoing items, we find that three and one-fourth of the four years are consumed, and no mention of engineering graphics. This leaves three-fourths of a year for courses which cannot find a place in the listed categories. Competition will be keen among specialized and applied courses for this space. It is vital for engineering education that engineering graphics, a subject used by all engineers in one form or another, not be forced to find its place among the miscellany of college offerings. To accomplish this, engineering graphics should be recognized as a science.

The matter of determining one's position in this scheme of things is largely a matter of semantics, the meaning of words. What is a science? Webster's Unabridged Dictionary gives the following definitions of the word "science":

1. Knowledge; knowledge of principles or facts.

2. Specific, accumulated and accepted knowledge which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws; knowledge classified and made available in work, life, or the search for truth; comprehensive, profound, or philosophical knowledge.
3. Especially such knowledge when it relates to the physical world and its phenomena.
4. Any branch or department of systemized knowledge considered as a distinct field of investigation or object of study.
5. Art or skill regarded as the result of knowledge of laws and principles.

Not one of these definitions could be construed so as to exclude engineering graphics from the sciences. The fact that we teach *some* technique does not make us different from the basic sciences which use laboratory instruction in part. In physics, for instance, there is laboratory instruction in measurement, and it is reasonably sure that the student is not told that he may use the micrometer carelessly or write a slip-shod report for fear that he may become a technician. The teaching of technique, or teaching by the laboratory method, does not preclude a subject from being a science.

Surely engineering graphics teaches a body of "accumulated and accepted knowledge which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws." Orthographic projection enables the engineer to represent three-dimensional objects on the two-dimensional surface of a sheet of paper. As a means of communication and a vehicle for design it has made possible much of the technical progress that has been made and will be made. The principles of projection have been accumulated, accepted, systematized, and formulated since the beginning of the nineteenth century, and the general laws of this phase of graphics are used daily by most engineers, particularly those who are engaged in *creative* work. It should be kept in mind that orthographic projection is used not only for delineation, but also for spatial problem-solving as an adjunct, and frequently a superior method, to numerical calculation. As taught by a progressive graphics department, engineering graphics is a rigorous discipline and a creative experience for the young engineering student.

Only those who judge subjects by long past experience and who neglect to inquire into what is being taught today fail to realize that the nature of engineering graphics instruction has changed radically in the last twenty years. How many engineering educators who are busy in other fields know that the descriptive geometry of the present day is far different and more useful than the subject they once learned? Are they aware that technique, while not neglected, is not emphasized to the time-consuming extent that it once was? Do they know that graphical mathematics is under continual investigation and is being taught in many of our colleges in basic graphics courses? Few fields of study can take comparable pride in their achievement and progress.

To sum up, engineering graphics is a fundamental, long-established, and growing science,—an engineering science worthy in importance to stand beside subjects such as strength of materials, fluid flow, physical metallurgy, etc., which are now in the ECPD list. If engineering education is to continue to be well-grounded, and creativeness to be encouraged, it should appear on the ECPD list under "Engineering Sciences." (Notice of the Mid-Winter Meeting of the Engineering Drawing Division may be found on page 235.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, University of Illinois, Urbana, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR OR ASSISTANT PROFESsor of Engineering to teach Mechanical Drawing and Plane Surveying at a branch college of the University of Virginia. Rank and salary dependent upon education and experience. Apply Dean of Engineering, Thornton Hall, University of Virginia, Charlottesville, Va.

INSTRUCTOR OR ASSISTANT PROfessor of Civil Engineering. Teaching experience desirable but not necessary. B.S. or M.S. in Civil Engineering required. Salary and academic rank commensurate with degree and experience. Contact Civil Engineering Department, University of Denver, Denver 10, Colorado.

PROFESSOR (ASSISTANT, ASSOCIATE, or full rank). Candidate should have M.S. degree; experience with High Frequency very desirable. Teaching Assignments: Basic Electronics, Communications and fundamental electrical engineering courses. Rank and salary will depend upon experience and training. School located on a large campus in Northwestern Detroit. Cooperative program. Position open for term starting either November 20, 1955, or February 21, 1956. NOV-1

STAFF OPENINGS IN CIVIL ELECtrical, and Mechanical Engineering; MS or PhD's desired. Salaries commensurate with qualifications. College of Engineering, Duke University, Durham, North Carolina.

ASSISTANT PROFS. OF MECH. ENGR. organize and teach courses in production processes, thermo. or drawing and design. 3 positions open Feb. 1. M.S. degree required. New building and equipment; good salary schedule. Write: Engr. Dept., San Jose State College, San Jose, Calif.

ELECTRICAL ENGINEERING POSItion to teach undergraduate courses. Ph.D. preferred, M.S. acceptable. Opportunity for graduate study, industrial consulting or research. Rank and salary open. Start February or September 1956. University of Santa Clara, Santa Clara, California.

ENGINEERING FACULTY OPPORTUnity at midwest state college. The Chairman in the Physics Department, salary open. Electrical Engineering Instructor or Assistant Professor in the Power field. Mechanical Engineering Instructor or Assistant Professor in Physics. Opportunity for graduate study. Housing available. Positions start September, 1956. NOV.-2

ASSISTANT PROFESSOR AND INstructor at small midwest engineering college in the Civil Engineering Department. Positions for spring or fall semester, 1956. Assistant professor must have special training or experience in sanitary engineering. Must have broad interests as applied mechanics and strength of materials as well as civil engineering are taught. Opportunity for graduate study at nearby university. NOV-3

New Members

ARNBAL, CARL ANTON, Assistant Professor of Engineering Drawing, Iowa State College, Ames, Iowa. James S. Rising, M. W. Almfeldt.

BAKER, JR., CARY FORNEY, Editor, Technical Education Department, McGraw-Hill Book Company, Inc., New York, New York. Jeanne I. Miller, H. Walter Shaw.

BAKER, PERLEY D., Dean of Norwich University, Northfield, Vermont. W. Leighton Collins, T. J. Dolan.

BOBCO, RICHARD PHILLIP, Instructor of Mechanical Engineering, Colorado School of Mines, Golden, Colorado. Albert L. Gosman, Hilbert F. Fletcher.

BOYD, JAMES STERLING, Associate Professor of Agricultural Engineering, Michigan State University, East Lansing, Mich. Carl F. Albrecht, Chester J. Mackson.

BRYANT, P. JOHN, Editor, General Motors Engineering Journal, General Motors Corporation, Detroit, Mich. Kenneth A. Meade, J. C. McElhany.

BURKE, PATRICK EARL, Lecturer in Electrical Engineering, University of Toronto, Toronto, Ontario, Canada. Adam J. Kravetz, Gordon F. Tracy.

CLELAND, SAM M., Associate Professor of Engineering, A. & M. College of Texas, College Station, Texas. W. E. Street, John P. Oliver.

DARLING, RAYMOND O., Associate Editor, General Motors Engineering Journal, General Motors Corporation, Detroit, Michigan. Kenneth A. Meade, J. C. McElhany.

ESSLER, WARREN ORVEL, Instructor in Electrical Engineering, South Dakota State College, College Station, South Dakota. K. F. Lindley, William J. Streib.

FIFE, JOHN PRESTLEY, Head of Humanities, Stevens Institute of Technology, Hoboken, N. J. Jess Harrison Davis, Lynn Merrill.

FOSTER, FRANKLIN LEROY, Director of Division of Industrial Cooperation, Massachusetts Institute of Technology, Cambridge, Mass. Arthur L. Townsend, Carl L. Svenson.

FROSLIE, HAROLD M., Head of Physics Department, Acting Engineering Dean, South Dakota State College, College Station, Brookings, South Dakota. Emory E. Johnson, Lee L. Amidon.

GARY, JAMES HUBERT, Assistant Professor of Chemical Engineering, University of Virginia, Charlottesville, Va. Lawrence R. Quarles, Orville R. Harris.

GLENN, CARROLL J., Executive Assistant to the Deans, St. Louis University of Technology, Saint Louis, Mo. Ross R. Heinrich, James B. Macelwane.

GOLDSTEIN, IRVING ROBERT, Associate Professor of Management Engineering, Newark College of Engineering, Newark, New Jersey. Olive J. Sizelove, William J. Jaffe.

GOMBERG, HENRY JACOB, Professor of Nuclear and Electrical Engineering, University of Michigan, Ann Arbor, Michigan. W. J. Emmons, George G. Brown.

GRANT, LEROY FRASER, Field Secretary, Engineering Institute of Canada, Kingston, Ontario, Canada. Maynard M. Boring, Thorndike Saville.

HANKINSON, GEORGE WILLIAM, Associate Professor in Civil Engineering, Northeastern University, Boston, Mass. Emil A. Gramstorff, W. T. Alexander.

HIPSH, HAROLD M., Professor and Head of Aeronautical Engineering, The Pennsylvania State University, University Park, Pa. Gerald K. Gillian, Jerome Steffens.

HORVIK, EIVIND, Acting Head of Physics Department, North Dakota State College, Fargo, North Dakota. Frank C. Mirgain, Robert N. Faiman.

HUANG, EUGENE YUCHING, Research Assistant Professor of Civil Engineering, University of Illinois, Urbana, Illinois. Ellis Danner, Thomas C. Shedd.

HUDSON, JACK L., Co-ordinator, College Co-op Training in the Technical Training Department, Chrysler Corporation, Detroit, Michigan. Donald C. Hunt, Earl C. Flarity.

JACKSON, JR., CHARLES ORLAND, Engineering Professor Placement Representative, Ford Motor Company, Dearborn, Michigan. Arthur L. Townsend, Carl L. Svenson.

KERR, ROBERT B., Instructor in Electrical Engineering, Johns Hopkins University, Baltimore, Md. John L. Artley, Robert H. Roy.

KOMMIT, DANIEL L., Instructor in Mechanical Engineering, New York University, New York, N. Y. Austin H. Church, Fred H. Posser.

LABENSKI, JOHN JOSEPH, Associate Professor Ordnance Research Laboratory, The Pennsylvania State University, University Park, Pa. Arnold Addison, Edward J. Tracey, Jr.

LANGSAM, WALTER CONSUELO, President of the University of Cincinnati, Cincinnati, Ohio. C. A. Joerger, H. K. Justice.

LARKIN, WILLIAM HARRISON, Engineer, Air Preheater Corporation, New York, N. Y. Newell L. Freeman, N. S. Hibshman.

MANZ, OSCAR ERNEST, Assistant Professor of Geology, University of North Dakota, Grand Forks, North Dakota. E. L. Lium, Robert J. McFarlin.

MOSILLO, FRANCIS ANTHONY, Instructor in General Engineering Drawing, University of Illinois (Chicago, Navy Pier), Chicago, Illinois. E. J. Caldario, M. V. J. Dembski.

OLIVER, JAMES H., Commercial Engineer, User Industries Sales General Electric Company, Schenectady, N. Y. W. H. Branch, D. Lee Chestnut.

OLSEN, CHARLES EUGENE, Instructor of Mathematics, University of Illinois, Chicago Branch, Chicago, Illinois. L. N. Blair, M. V. J. Dembski.

PAAPE, CHARLES WILLIAM, Associate Professor of History, Carnegie Institute of Technology, Pittsburgh, Pa. W. Leighton Collins, T. J. Dolan.

PETERS, RALPH EDWARD, Aeronautical Engineering Coordinator, University of Cincinnati, Cincinnati, Ohio. H. C. Messinger, Bradley Jones.

PETERSON, THOBURN FINDLEY, Assistant Professor of Engineering Drawing, University of North Dakota, Grand Forks, North Dakota.

ROHSENOW, WARREN M., Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Bonnie-Blanche Schoonover, Arthur L. Townsend.

ROSS, C. HUDSON, Associate Professor, Clarkson College, Potsdam, N. Y. W. H. Allison, Charles N. Henshaw.

SALINE, LINDON E., Regional Manager-Headquarters Recruiting, General Electric Co. —Bldg. 69, Schenectady, New York. W. Scott Hill, Henry G. Hutton.

SEID, ROBERT BERNARD, Instructor of Engineering Drawing and Descriptice Geometry, Queens College, Flushing, New York. L. O. Johnson, Irwin Wladaver.

Stinson, JAMES R., Instructor in Geophysics and Geophysical Engineering, St. Louis University Institute of Technology, Saint Louis, Missouri. Ross R. Heinrich, James B. Macelwane.

STURROCK, WALTER, Illuminating Engineer —Large Lamp, General Electric Company, Cleveland, Ohio. M. M. Boring, Russell C. Putnam.

TINETTI, GEORGE KENYON, Machine Shop, General Motors Institute, Flint, Michigan. C. L. Fanning, F. L. Mackin.

TINKER, ROBERT NORMAN, Assistant Professor of Engineering Drawing, Rose Polytechnic Institute, Terre Haute, Indiana. Ralph M. Ross, Herman A. Moench.

VANNAH, SHERMAN, Associate Professor of Mechanical Engineering, Tufts University Medford, Massachusetts. Kenneth N. Astill, Edgar MacNaughton.

VONDERLAGE, FRED C., Director, Oak Ridge School of Reactor Technology, Oak Ridge National Laboratory, Oak Ridge, Tenn. W. Leighton Collins, Maynard M. Boring.

WAINES, RUSSELL TALBOT, Assistant Professor of Mechanical Engineering, University of Toronto, Toronto, Ontario, Canada. Irvine W. Smith, W. G. McIntosh.

WANG, SHOU-LING, Assistant Professor of Civil Engineering, Clarkson College of Technology, Potsdam, New York. W. H. Allison, Preston W. Smith.

WILLIAMS, GEORGE LOUIS, Instructor of Physics, Newark College of Engineering, Newark, New Jersey. Thomas J. Blisard, Paul O. Hoffman.

WOLFE, JOHN K., Manager, Advance Degree Personnel, General Electric Company, New York, New York. M. M. Boring, W. Scott Hill.

YOUNGMAN, LESTER A., Associate Professor of Physics and Engineering, Pan American College, Edinburg, Texas. W. Leighton Collins, W. M. Lansford.

51 New members this list
111 Previously added

162 New members this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute of Technology	April, 1956	J. W. Graham, Jr., Carnegie Institute of Technology
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Nebraska	Oct. 22–23, 1955	J. K. LUDWICKSON, Kansas State College
Michigan	Wayne University	May 6, 1956	G. H. Howell, Wayne University
Middle Atlantic	New York University	Dec. 3, 1955	C. C. Carr, Pratt Institute
Missouri-Arkansas	St. Louis University	April 7, 1956	J. B. Macelwane, St. Louis University
National Capital Area	Capital Radio Engineering Institute	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	University of Maine	Oct. 8, 1955	W. S. DAVIS, University of Maine
North Midwest	South Dakota State College	Nov. 4–5, 1955	L. L. Amidon, South Dakota State College
Ohio	Ohio State University	April 28, 1956	E. C. Clark, Ohio State University
*Pacific Northwest			J. B. Morrison, University of Washington
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1955	R. G. Moses, Pasadena City College
*Rocky Mountain	Denver University		W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 14–15, 1955	B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

* No Date Set.

Do You Know—

► Now it is December and the Christmas season already is here! To all of you I want to wish a sincere and very Merry Christmas. The office staff joins me in extending these greetings. We sincerely hope that "Peace on Earth, Good Will toward Men" will be a reality for all of you, and that each of you can look forward to the New Year with enthusiasm and hope, the hope that must spring eternal if we are to do better jobs of teaching.

► While each of you is making your New Year's Resolutions to do a better job than ever before, there also will be a few new things in ASEE during the coming year. This is the last issue of the Journal for which Professor C. E. Watson is responsible; Professor E. C. McClintock, the new Editor, "takes over" in January. In singing Auld Lang Syne on December 31 we should turn to Professor C. E. Watson who has capably served the Society for many years as Editor of the JOURNAL and Assistant Secretary. "Wat" stepped in when help was sorely needed, and his big shoulder on the wheel brought results which the Society appreciates. And in saying thanks to you for the services you rendered, Wat, we also wish you well in whatever your new extra-curricular activities will be. Your many friends will continue to look for you at the Annual Meetings.

► In order that the Society and its membership have a better opportunity to know of the work done by its representatives to other organizations and committees, all members so appointed this year have been asked to submit a report of their activities at the end of the year. Such information as will be of general interest to the Society will be printed in the JOURNAL.

► When mailing lists for summer schools, etc., are made up by Divisions there is a need for knowing the Divisional interest of each *Administrator*. It is too late to do much about the '56 Yearbook, but we want to get started for the following year. So, if you are listed as an *Administrator* in the Occupational Distribution of Membership, either educational or industrial, please inform me of your divisional interest. Some of you asked that administrators be listed twice, but the Executive Board believed that listing the divisional interest after the title of the administrator was a satisfactory procedure to follow.

► Most Section Chairmen have been sending copies of their programs and minutes of meetings to the Secretary, and he is pleased to receive them. It is now requested that a copy *also* be sent to the Vice President in charge of general and regional activities, F. C. Lindvall, Chairman, Division of Engineering, California Institute of Technology, Pasadena, California. This procedure will enable him to become better informed on one aspect of his duties.

► At the Annual Meeting several suggestions were received that the Society should adopt some kind of a membership card as a receipt for dues payment. At its September meeting the Executive Board questioned the merit of the additional office work and expense and agreed not to depart from the present method of having the members' check serve as his receipt.

► Several inquiries have been received from time to time about the establishment of a clearing house or employment service for retired (and other) personnel, at the Annual meeting as well as throughout the year. The Executive Board at its meeting on 10 September agreed it was not a function of the Society to operate an employment service, particularly since Engineering Societies Personnel Service,

Inc., already has been established to serve the engineering profession. Most of our members probably are also members of one of the societies sponsoring that service.

► The Drawing Division is having its annual Midwinter meeting on January 27 and 28, 1956, at the Illinois Institute of Technology. Between 100 and 150 usually attend this meeting but indications are that this year's attendance will break all previous records. Highlights of the program are the two General Sessions at which technical papers will be presented and an inspection trip through the Chicago Tribune plant.

► The College-Industry Conference, sponsored annually by our Relations with Industry Division, has a "Humanistic-Social" theme this year. The dates are January 25 and 26 and the place is Marquette University, Milwaukee, Wisconsin.

► The Executive Board has formally approved the plan to submit all Section-winning papers of the YET Paper Contest to the Editor for possible publication in the JOURNAL OF ENGINEERING EDUCATION, and recommends to the Editor that he encourage the YETs by publishing as many as possible of the Section-winning papers. The Executive Board also recognizes that any paper submitted in a Section contest—even if it is not the winner—can be submitted to the JOURNAL for publication, just as any other author can submit a paper for publication.

► Don't forget that ECRC's award for outstanding contributions to research in engineering and engineering sciences in American colleges and universities will be awarded for the first time at the 1956 Annual Meeting. The recipient of the award is to be selected annually on his achievements in and contributions to one or more of the following areas: original research, research administration, leadership influencing the productive research of others, and the effective application of research results to the advancement of engineering education. Nomination forms and a brochure explaining the award have been sent to all Deans, Directors of Research, Members of the General Council, and Section Chairmen. Additional copies may be obtained from the Secretary's office.

► Please note that the audit for the fiscal year 1954–55 appears on page 397. From its examination it becomes apparent that the change in dues structure of a few years ago is enabling the Society to reach a sound financial position. Despite the increase in expenses resulting from the change in Secretary and the moving of the Society officers from Northwestern University to the University of Illinois, the Society operated "in the black" and was able to add a significant amount to the unappropriated reserve. The Finance Committee has recommended that this reserve be at least 70% of the operating expenses for one fiscal year. We haven't reached that goal yet, but it is coming closer. But in feeling good about the budget don't overlook the large incomes from JOURNAL advertising and dues from institutional members. Maintaining these totals at a high level means the making of constant efforts—by your officers, appropriate committees, and by *you*. Each of you, as an individual member of the Society should do all you can to interest industries in membership and in advertising. Just recently I made a casual remark to a salesman about the JOURNAL being a good place for his firm to advertise. Two months later we ran their first ad! Most of you have salesmen calling on you, how about you giving JOURNAL advertising a plug and selling him?

Merry Christmas to all of you from all of us!

NAOMI GARMAN
LOUISE CHAMBLISS,
ELSIE O'BRIEN
E. C. MCCLINTOCK
W. LEIGHTON COLLINS,
Secretary

Industrial Research and a Profile of the Research Worker*

By DR. E. W. ENGSTROM

Executive Vice President Research and Engineering, Radio Corporation of America

An industrial research administrator should be very much at home among engineering college administrators and directors of engineering college research. These three fields of endeavor have much in common. The engineering college provides much of the trained personnel which is so essential to industrial research. Sometimes industrial research provides experienced leadership for the engineering colleges. The engineering colleges are also the producers of research results important to industry. Some of these results are obtained in cooperation with industrial research laboratories. Others are independent contributions of engineering colleges. Never have relations between engineering colleges and industrial laboratories been closer or more friendly.

I shall present for your consideration ideas, principles, and facts which have been developed for their application to industrial research. That they have some application to the engineering-college field I have no doubt. However, I leave it to you to find such utility as they may have in your particular lines of endeavor.

First, I shall trace some of the steps whereby the scientist and the engineer came to their present status in industry. This will serve to emphasize the team concept in industrial research and technology. This concept is basic to the solution of a large proportion of the problems of industrial research administration.

A second concept of equally wide application is that of the importance of the human nature of the research workers. In the second portion of my paper I shall, therefore, discuss what industry requires of the research worker and the character and motivation of the individual research worker as we find him, not as we might wish him to be. Much of what I shall say on this subject is based upon an informal survey which was conducted among my associates at RCA Laboratories. The purpose of the survey was to obtain a more objective view of the research worker and to broaden our comprehension of the human side of research. To the conclusions of this survey I have added from my own experience.

Environment in Research

Until about one hundred years ago neither science nor engineering was recognized as a normal component of industry. During the Industrial Revolution of the preceding century, industrial development stressed empiricism rather than science. Progress depended to a large extent on the development of machines. This development, in turn, depended on mechanical inventiveness.

A century ago, research men in the universities were beginning to lay the foundation stones of modern science. This university research was conducted without any conscious consideration of practical applications. It had no connection with industry. This fact I emphasize because of its importance to an understanding of the scientific work of the time.

The art of engineering goes back to antiquity. However, the professionally trained engineer did not appear on the

* Presented at the Annual Meeting of ASEE, ECAC–ECRC Dinner, Penn State University, June 21, 1955.

American industrial scene until after 1850. From 1850 until 1900 both the inventor and the trained engineer played important roles in the translation of scientific results into practical applications. In these advances the trained engineer gradually assumed a larger part. In many instances he became an inventor as well as an engineer. The rise of the engineering college was both a cause and a result of this rise of the profession of engineering.

At the turn of the century, understanding in the physical sciences made a great surge forward. This, like the previous scientific advances, was the work of research men in the universities. There was the discovery of X-rays, electromagnetic radiation, the electron, radium. The nature of radioactivity was revealed and the development of the quantum theory was begun. We might well consider this period as the beginning of modern science.

Before this time, almost no scientists were employed in industry. In fact, many scientists of the late nineteenth century felt that a connection with the application of scientific discoveries placed a stigma upon them. Accompanying this attitude, experienced people in industry, including engineers, thought scientists to be hopelessly impractical.

Technology prior to 1900 was not complex and scientific knowledge was limited. Intense specialization was not required to achieve expertness. This, however, was soon to change. Specialization became a necessity, both in science and in engineering.

After 1900, scientists in slowly increasing numbers were employed in industry. The beginning of this association of scientists with industry marked the birth of industrial research. Science, thereafter, came to have increased meaning and purpose in industry. Working relationships between scientists and engineers were developed. Research by teams of scientists and engineers began.

At the beginning of this liaison between science and industry, the place of the engineer in industry was already well established. The engineer's functions were clearly defined and understood.

As the scientist-engineer team developed, the old-fashioned inventor began to disappear. I mean the inventor with natural aptitude and intuition but little knowledge of science. This was a natural consequence of the increasing complexity of technology. However, the natural aptitudes of inventiveness had not disappeared. They had simply ceased to be individually conspicuous in the old way. The individual contribution in modern technology reflects a background comprising a great variety of specialized scientific and technical skills. Invention now flourishes in a setting and atmosphere of science, an environment planned for creativity and invention.

Now at mid-twentieth century, the places of the scientist and the engineer are both well established in industry. A full partnership has developed. This is so much the case that the earlier clear-cut distinctions of function now cannot always be recognized. A bridge of communication has been formed. This bridge is between the scientists and engineers in industry on the one hand, and the scientists in the universities on the other hand. The old divisive feelings are gone. The practical applications of science have been greatly speeded as a result.

However else we might characterize the fast-moving last half century, it was above all an age of science. This was primarily the result of two developments—the organization of the scientist-engineer research team, and its acceptance in modern industry. The growth of research in the engineering colleges, which led to the organization of the E. C. R. C., played an important part in this development.

Before the twentieth century, as I have said, scientific advances were made by research men in universities, working without thought of applications. New products were primarily due to the independent inventor, working with little scientific knowledge but with great natural aptitude.

The growth of the research team, composed of theorists, applied scientists, and

development engineers, is distinctly a phenomenon of the twentieth century. In the period prior to the turn of this century, scientific progress did find practical application. However, it was at such a slow rate that a scientist who conceived a new theory rarely lived to see the utility of his idea. Now, with our modern research teams, research men can formulate a new concept. They can see it applied in some positive way to contemporary living. They can still be on hand to contemplate the impact which it makes on the world, whether for good or for ill.

The Research Worker

Today, forward-looking industries are fully aware of the possibilities of research. They are investing more and more in research. Research has taken an important place in business administrative planning. All this is done because of the conviction that research is necessary and provides long-term benefits.

We do not now question the place of research in industry. Rather, we ask how may industrial research be made more effective.

An effective research team must include creative people having all the needed skills. Also, it must be so organized and supported as a satisfy the motivation of these creative research people.

First, the research team must be so constituted that its members work smoothly together.

Secondly, the team must be organized so that there are proper cooperation and understanding between the research workers and the nontechnical service personnel.

Thirdly, there must be cooperation between the members of the team and the development and production engineers who must carry the research results into commercial production.

The industrial research organization should take into account the personal characteristics and motivation of the research man. Such an organization is in the best position to integrate its creative people into productive research teams meeting these requirements. Likewise, the research man should understand his own personal characteristics and motivation and the personal characteristics and motivation of his colleagues. With this understanding he is in the best position to select employment which will give him continuing satisfaction. Therefore, it is valuable to consider these matters.

We have talked and heard much recently about the great shortage of engineering and scientific personnel, yet America does have a large reservoir of talent. It is not unlimited but neither has it ever been completely tapped. The problem of manning our growing research laboratories is one of recruitment, of stimulation and encouragement. Suitably talented young people must be induced to complete the proper university training. The engineering college and the A.S.E.E. are making an important contribution at this stage.

Do we know what to look for as we recruit men for research? How can we make the best use of the people now engaged in research? We will have insight for the solution of this problem if we gain a better understanding of the kind of men needed for industrial research and of the character and motivation of the individual men now engaged in research.

It is evidently not possible to draw a single profile as an absolute standard for the man in industrial research. There is no ideal profile of the research worker as industry would like him to be. Nor can the actual worker, as we known him in the industrial research laboratory, be represented by a single profile. Since research workers vary as they do, it is fortunate that the requirements of industry vary also. These requirements vary for different units of industry. They vary for differing outlooks on research, and with the differing ideas of the particular persons administering the research. As we look at research workers as people, as we examine their personal likes and dislikes, as we take into account their individual and collective characteristics, many variations are found. There are as

many combinations as there are individual research workers. Nevertheless, a pattern of the nature of the research worker seems to develop. It is this pattern which we shall examine now.

Industry's Requirements for the Research Worker

What does industry look for as it recruits men to carry on its research programs? What are the requirements for a successful industrial research worker?

1. *Creativeness*

Among all who participated in our survey, there was general agreement on one requirement. Creativeness was placed at the top of the list of required characteristics. The creation of new understandings, new principles, new products, or new services—these identify an activity as research. Therefore, creativeness must be a basic research requirement. Members of research staffs are not equally creative. In fact, a staff composed exclusively of highly creative members would be unmanageable. On the other hand, a staff of noncreative members would be sterile. A research staff is effective when all its members respond to originality, when all have some degree of originality themselves, and when some of them are highly creative.

Creativity does not respond to attempts at definition or specification. There are no measures of creativeness which may be applied to an individual during pre-employment interviews. The creativeness of a research worker is not learned by brief contact with him. It is learned by observing him in extended living, preferably in a research environment.

Those who conduct employment interviews have various opinions and convictions regarding the gauging of creativeness. However, our experienced interviewers do not feel that they can estimate creative ability with any practical degree of accuracy in an interview. In general, the interviewers recommend employment if a young man shows a good reasoning ability and a good grasp of fundamentals. This is true almost regardless of other desirable qualities which they think he may lack.

The interviewers are concerned about creative ability or promise of creativeness. In spite of this concern, they make few positive statements in their interview reports regarding this important characteristic. They believe that persons who cannot reason clearly from fundamentals are not likely to be creative in research. From this belief stems the emphasis placed on the ability to reason clearly from fundamentals. Similarly, our interviewers have regard for broad knowledge and extensive interests. This is because of the close relationship between creativeness and the characteristics of imagination, and the urge to investigate and to learn.

All this is important because a research organization thrives if it recruits creative members for its staff. It is also important because a research man prospers if he possesses creativeness. The research administrator needs to know a prospective staff member's promise of creativeness and the prospective research man needs to know his own potential creativeness.

> *Industry expects its research workers to possess originality and to develop and use their creative powers.*

2. *Training*

Training in fundamental science is second only to creativeness as a requirement for the research worker. Scientific training is placed second to creativeness. This is because all other assets, including good scientific training, become ineffective without the creative mental traits which I have been discussing. However, creative ability must be backed by fundamental knowledge and specific skills if the research worker's creation is to mature into useful form.

Knowledge and training in specific fields are valued but they are definitely secondary in importance to an understanding of the fundamentals of mathematics, physics, chemistry, or engineering.

Industry does not expect all its workers to undergo a standardized training any more than it expects them all to possess equal creative talents. It is usual for aspirants for research positions to acquire or to desire university training at graduate level. Such preparation is valuable because of the knowledge and training it provides. It is valuable also because it adds another stage to the selective process by which it is established that the particular person is both interested in and suited for research.

For the research worker, the educational process, the acquiring of knowledge, or the development of skills should never diminish or cease. The research process itself is subject to the same obsolescence that it brings to the objects of its research. The research worker, therefore, must continue to be a scholar of science.

Knowledge gained in the university may be looked upon as a set of research tools. All agree that certain of these tools are basic and necessary. It is essential to have the ability to put the tools to use and to acquire supplementary tools as the need appears.

> *Industry expects its workers to have acquired basic scientific training, to know how to use it, and to continue to improve their knowledge and skills throughout their research careers.*

3. *Character*

When these requirements for the research worker were first set down, following our survey, character was placed as the first item. It is still considered the basic requirement. However, it must, for practical reasons, follow creativeness and training in our list of requirements. Often character is not given appropriate consideration by younger research workers, nor do they appreciate the importance placed upon character by research administrators. Perhaps research administrators themselves have not adequately evaluated the importance of character. Whether or not it is so designated, character is a prime requirement. Integrity of purpose is essential to any research. Research deals with nature, and nature does not reveal her secrets unless the quest for them is conducted with technical and scientific accuracy and honesty. Complete reliability in prosecuting a research program is richly rewarded, yet it is rarer than one might think.

> *Industry expects its research workers to be dependable and of good character.*

4. *Vision*

The research man must also have vision. He needs the ability to visualize the possible results of an investigation. He needs to see the application of a technique before its development is complete. Creativeness coupled with vision to treat the creation objectively makes for greatness in research.

5. *Energy—Drive*

Having found creative insight, one then looks for initiative. It is initiative that gets the research under way. Once the research is under way, one looks for enthusiasm to support the drive for progress. One looks for courage to take large steps into the territory of the unknown. One looks for perseverance to continue even though the going becomes difficult and discouraging. One also looks for persuasiveness in dealings with assistants, associates, and superiors. All these traits are manifestations of energy and intensity of drive. They represent, when accompanied by the necessary abilities, the potential for deep penetration into the new. They reduce the speculation involved in research by insistence upon positive and useful results.

> *Industry expects research workers to be energetic and to drive their research forward toward established goals.*

6. *Scientific Inquisitiveness*

Research workers who are extremely productive of new ideas are persistently

expressing scientific curiosity or inquisitiveness. They have a continuing and unquenchable thirst to understand old and new situations and to relate these to other situations.

Industry expects its research workers to be inquisitive in all matters concerned with the fields assigned and the research objectives established.

7. *Practical Outlook*

Industrial research is done for the benefit of the industrial organization supporting it. In order to be of greatest benefit to its industrial sponsor, a research program must have a practical outlook. Not all research results are positive. Many results are of only nominal worth. However, a well planned and well executed program should provide results which are rich in current or potential values. Such research can be done best in an atmosphere of common sense. Research is sometimes thought of in lay circles as an ivory-tower enterprise. This is certainly an outmoded, if not a completely erroneous, impression. In research, as in other fields, enhanced results are obtained by the use of common sense in the establishment of objectives and in the work to attain them.

A practical outlook develops with training and experience in a suitable environment. Constructive action should be taken to begin the development of this practical outlook while the prospective research worker is still in the educational institution. The educational institution should be certain that its staff members are equipped by attitude and by experience to teach this practical outlook by example. The new research worker in industry should be given early indoctrination as to practical values. He should respond to practical considerations throughout the development of his career.

Industry expects its research workers to have and develop a practical outlook, to approach their work with common sense.

8. *Attitudes*

A research worker's attitudes are observed at the pre-employment interview. They continue to be observed as long as his employment lasts. For the prospective staff member, the initial approach is important. Does he show interest? Does he indicate willingness to work and prove his value? Does he give the impression of being suited for research? These attitudes become still more important in a practical sense as the research worker faces his first, second, and succeeding tasks. Then he begins to reflect his attitude in dealing with associates and superiors.

The complexity of modern research demands that the work be performed by a team. Effective team research necessitates a balance between one's personal ambition and one's understanding of the rights and ambitions of one's associates. Productive teamwork also requires an interest in the functioning of the laboratory as a whole, an interest which will generate ideas for other groups as well as one's own, an interest which will lead to an understanding of the place of particular projects in the program of the entire laboratory. A research organization can tolerate a few self-centered, temperamental, individual workers. However, if the organization is to thrive, nearly all its members must be cooperative. They must be able to get along with each other. They must be imbued with the spirit of team play.

Industry expects its research workers to have wholesome attitudes toward their work and toward the persons with whom they come in contact. Industry expects its research workers to understand and practice cooperation.

9. *Research Environment*

Research organizations that have established records for fruitful results have also developed understanding of the nature of research and the characteristics of the research worker. These organizations,

in administering their research programs, are tolerant of new staff members. They understand the speculative nature of research. They appreciate the need for the research worker to keep his knowledge and training up to date. They support him in his desire to do this by individual study and through outside contacts.

The research worker is, as a result, in an atmosphere of freedom in the use of his time. His direction may be more by suggestion than by specification. This is proper, for experience indicates that research thrives in such an environment. However, the research worker must understand and respect the purpose of these freedoms and tolerances if they are not to be abused.

Industry expects its research workers to make proper use of the freedoms of the research environment.

10. *Mental Youth*

While the evidence is by no means conclusive, there is reason to believe that the most revolutionary creative thoughts come to a few research workers during their first decade of work. It seems that the average research worker's most original and creative work comes before the close of his second decade. His best balanced contribution of original work, tempered by experience, is likely to occur during his second or third decade. Beyond the third decade, the average research worker's strongest characteristic is likely to be his judgment, his qualities of leadership, or his effectiveness in training younger staff members. For some, however, these generalizations do not apply. A few complete their careers with creativeness undiminished.

The relationship of age to creativeness is a relatively unknown field. We have too few facts, and current knowledge is not controlling as far as the individual is concerned. What industry requires is a continual intake of young research workers and an understanding of how best to use those of advancing age.

Industry expects to freshen its research staff by continually adding young members, and industry hopes that a share of its research workers will retain their mental youth.

11. *Other Desirable Qualities*

There are several additional qualities which are desirable in a research worker. I shall briefly mention salesmanship, manual dexterity, and the ability to speak and write clearly.

a. *Salesmanship*

Industry expects its research workers to be salesmen of research. The research worker must first sell his ideas for a research project to the Research Director before work can begin. After finishing a research job, he must sell the results to those in charge of commercial activities.

b. *Manual Dexterity*

A degree of manual dexterity is of considerable value in today's research. A large part of modern research employs experimental rather than theoretical techniques. Therefore, it is important for the research worker to be able to transfer his ideas quickly into successful practical experimentation. Ability with one's hands is helpful in this.

c. *Ability to Speak and Write Clear English*

The ability to express oneself well in speech and writing is important to the research worker. This is because the results of research are mainly ideas and these must be conveyed to others in words and diagrams. The research worker who lacks a good command of language is severely handicapped. He is unable to communicate satisfactorily the results of his research to those who could make good use of them.

Summary

Having reviewed in some detail industry's requirements for the research worker, I shall now summarize.

Insofar as they can choose, industrial

laboratories pick for their research teams men who are creative and men who are well trained in the fundamentals of science. They choose men of good character, men of vision, men of energy and drive. They look for men who have scientific curiosity but who, at the same time, have a practical outlook, men who practice cooperation and can make good use of the freedoms of the research environment. They hope for research workers with continuing mental youth. Industrial laboratories also value research workers who are good salesmen of research ideas. They value men who are adept with their hands, and who can express themselves well in speech or writing.

When we are considering a person with reference to a particular job, we do not always weigh the desired research qualities the same as when research qualifications are discussed in general terms. We do not want exactly the same type of person to fill all industrial research jobs. Because of the nature of a particular job, any one or two of the qualities just discussed may be required to a greater degree than the others. A proper balance of men with varied characteristics is the secret of an able research team.

The Research Man, a Human Being

Having examined what industry requires of the research worker, I shall now direct attention to the research man as an individual, as a human being.

1. *Motivation*

Any list of desirable qualifications for men in research runs the risk of being over-idealized and utopian. It is, without doubt, necessary to have an understanding of the essential qualities which make for a successful research worker. But, this is not enough. We also need to know concretely the actual men in research. We need to know the make-up of the research worker—how he is motivated, what factors draw him into research as a career, and what keeps him satisfied year after year.

In short, taking the research man as he is, and not as we would like to have him be, we need to know something about his thinking, about his desires, and about his needs as a human being. With these facts in mind, we can then discuss how he will fit into the modern research team and what we can expect of him as a member of that team.

Although our survey disclosed a wide difference of opinion regarding the characteristics of a research man, our associates seemed to agree fairly well on his motives.

a. *Intellectual Curiosity*

Everyone placed curiosity at the top of the list of motives. The urge to investigate and explore is the mainspring of the research man. His present curiosity stimulates more curiosity for tomorrow, and so on into the future.

When does this intellectual curiosity, this urge to investigate, first begin to show itself? There seems to be good evidence that it begins in childhood or early adolescence. Little by little, the scientist-to-be accumulates a large store of knowledge. He does this through his interest in natural phenomena and through his own observations. By the time he reaches high-school or college age, many of the "building blocks" that go to make up the research man are formed. Because of the great store of knowledge which he has accumulated subconsciously, he is able, even at that age, to reject almost automatically many unfavorable alternatives in seeking the solution to his scientific problems. In school he finds that he excels as soon as he begins to take courses in science. He finds a joy in learning that he never experienced before. The cels as soon as he begins to take courses arouses compelling interest, and his curiosity grows under the stimulation of scientific education. Sooner or later, he develops a burning desire to explore beyond the obvious and the known.

Another motive which urges the research man on to investigate and explore

is discontent with the current order of things. A good research man is not easily satisfied. He responds to the challenge of a problem. His imagination permits him to see possibilities for improvement, and his nature drives him to seek solutions.

b. *Will to Create*

The will to create is another important motivation for the research man. Most scientists take pleasure in creating something new. There are many in research who would pursue their investigations for their own personal satisfaction in accomplishment. They would do this regardless of papers presented, credit given, patents granted, financial rewards, or other types of recognition. However, the research worker does crave recognition from those with whom he works and, eventually, from those in his scientific field throughout the world.

Some say that the satisfaction the research man gets in his creating is a satisfaction of his ego. There is evidence that the scientist has a strong ego. It may be the same kind of ego that is satisfied by a man taking up a hobby. He enjoys demonstrating his excellence in his hobby, even if only to himself. He takes pride in showing himself what he can do.

c. *Financial Incentive*

How strong is the motive of financial reward? Does the research worker's dedication to a life of research mean that he is not interested in money? Certainly not! But it does seem clear that the financial incentive is not all important. Also of importance to the research worker are the facilities and opportunities to satisfy his curiosity and intellectual recognition for his contributions.

This does not mean, however, that the research worker disregards financial compensation. Neither does it mean that he disregards the dollar as a measure of success. But it does mean that the average research worker is not a fortune seeker, nor is he envious of those with large personal fortunes.

d. *The Role of the Wife in the Research Man's Motivation*

It should be noted that very often the research man's wife is more concerned about recognition for her husband than he is himself. Part of her desire for this recognition may be due to true respect for her husband's ability and performance. Part of it may be due to ambitions of more than keeping up with the Joneses. One of my associates has said that it might be more effective to give the prizes, awards, the compensations and the titles, to the wife than to her scientist husband. No matter what the source of the wife's ambitions, they are a real factor in the happiness and performance of the research man. Hence, they are another important element in the research environment.

e. *Idealism*

If the research worker is not strongly motivated by financial considerations, is he on the other hand an idealist? Here the evidence is not too clear. It is true that some enter the field of research with a vision of opportunities for benefiting mankind. On the other hand, many others see in a research career an occupation not more worthwhile than many other professions. They see only one for which they are well fitted by their particular abilities.

Sooner or later, the idealist may come to see that a scientific discovery is not of itself either good or bad. It is neither moral nor immoral, it is amoral. The true scientist will reach out to discover the unknown regardless of the consequences to humanity and regardless of moral implications. But, this brings some scientists to a dilemma. For example, during the war, many research men were "brought up short" in contemplating the death-producing instrumentalities they were creating. More recently, there are those atomic scientists who are unable to reconcile themselves morally to the new order they helped to create.

2. *Personal Characteristics*

Most of those questioned in our survey believe that the variations in human characteristics or personality traits are as great among research men as among human beings in any other grouping. Nevertheless, they believe that the research man does tend to have a few particular personal characteristics.

For one thing, the research man is often found to be essentially an individualist. He usually has strong opinions. He may object to being told what to do or how to do it. On the other hand, he is apt to be tolerant, even if only to a limited extent. He has proved himself wrong just about as often as he has proved himself right. Consequently, he does not insist that his way of thinking is the only way.

The research man is likely to be retiring rather than outgoing in personality. He may not start out that way, but his single-minded interest in research may make him so.

The research worker is a straight thinker. He is logical minded. He is able to reason objectively, particularly in matters of scientific research. He proceeds from a premise to a conclusion. He will not be persuaded of the truth or falsity of a certain scientific theory until he reaches that conclusion by logical processes.

Conclusion

I have sketched the developing environment for industrial research. I have outlined what industry requires from the research worker. I have also said something of the character and motivation of the individual in research.

I have stated that it is not possible to draw one standard profile for the man in research, that this concept of a "standard member-of-staff" should in fact be avoided. It would be regrettable if we should set up standardized criteria and should begin to apply these criteria rigorously in employing members of a research staff. Research thrives on freshness of viewpoint and on differences of approach to the solution of problems. These conditions we achieve by varied environments of training, by differences in the prominence of the several characteristics we have been discussing, and by a continual flow of persons newly come from the halls of learning.

Our great problem today is the proper cultivation and exploitation of the nation's intellectual resources. We must learn to make the most effective use of our research staffs. We must know what we want and what we can expect to get from the research worker. We must understand his motivations and his personal characteristics. Having an understanding of these things, we must provide an environment conducive of good research. We must use creative imagination in the administration of research. We must follow this with sound engineering and good business planning. This is effective research, the kind of research which will maintain our position today and control our destiny tomorrow.

ASEE ANNUAL MEETING

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—— AIM FOR AMES IN 1956 ——

Iowa State College

Uses of the Laboratory in the Teaching of Electric Machinery Courses*

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The use of the Laboratory in courses on Electric Machinery is related intimately to the broader issue of what the true educational aims of these courses are. It is the uncertainty of these aims that is the matter of concern.

We may recognize that courses and laboratories, in established forms handed down through decades, have little appeal to most students and—even worse—seldom seem to contribute anything lasting to their professional stature. However, before leveling accusations of obsolescence against these courses, before raising the specious argument of the more glamorous competition of newer subjects, and before accepting drastic decisions in the reshaping of the curriculum, it may well be in order to examine how this lamentable situation has been reached.

Indeed electric machines are no longer in a stage of dramatic development. Their basic types resulted from some marginal thinking of Physicists who, some eighty years ago, were concerned essentially with the building of electromagnetic field theories. Technically minded people grasped the practical significance of those inventions in terms of industrial conversion of energy and, with shrewd ingenuity, proceeded to their reduction to practice in a remarkably short time. Nearly all machines of present usage were found displayed in workable commercial form at the St. Louis Exhibition of 1904.

This technological development was accompanied and followed by a fruitful period of fundamental studies, investigating analytically the electrodynamical problem and also associated aspects, thermal and mechanical. Within one decade, i.e. up to the first World War, magnificent scientific treatises were produced, such as the classic ones of Arnold, which discussed comprehensively electric machine theory, both fieldwise and circuitwise, and gave sound criteria of design and experimentation in the laboratory and on the test floor.

Further progress went on from that point, of course, but soon the problems to be solved became more specific and exacting, reaching quite frequently beyond the level of undergraduate understanding and interests. (In fact, it is not the lack of problems, but rather their present formidable complexity that makes it comparatively difficult to choose suitable subjects even for doctoral dissertations in the field.)

The recognition that the largest part of the content of present undergraduate courses can be traced directly to treatises which are more than 40 years old, however, should not constitute an accusation of obsolescence in itself; the basic understanding of any given field of scientific knowledge is not a matter of passing fashions. But the accusation may be more properly directed to the general educational aims that we may intend to achieve in the curriculum. The purpose of courses on electric machines, as conceived some 40 years ago, was to prepare supertechnicians well versed in the immediate solution of everyday questions of design, testing and trouble-shooting of

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these machines. With the tremendous expansion of the art we have learned that all this is neither feasible nor truly desirable. Yet the readjustment of machinery courses and laboratory work to the changed needs seems to have taken place only in the narrow form of a retreating fight. One hears arguments about number of courses and units, about length and number of laboratory assignments; half-hearted concessions are made to "drop" this or that machine which may be technologically "less important" than others, reducing laboratory assignment to a minimum number of standard tests.

In a way, this kind of approach reminds one of tourists visiting a large gallery of art, pressed for time but dutybound to "see" as much as possible. They may decide reluctantly to skip the third floor or even to limit themselves only to those works of famous painters which they understand to be a "must." Then, with an eye on their watch, they rush hurriedly to check that the frames of those paintings really hang where the guidebook says they should. The result is confusion and tiredness rather than enjoyment and art appreciation.

The Real Question

In our appraisal of the overall curriculum, at the Carnegie Institute of Technology, we have tried to discard completely the educationally fallacious argument that electric machines may be "important" in terms of their technological usage or in terms of statistics on electrical engineers employment. The question is rather whether the analytical and experimental study of electric machines is a subject in which the understanding of physical laws can be extended and deepened and in which significant engineering problems can be attacked profitably by engineering methods at the level of maturity reached by the students.

The answer is emphatically in the affirmative. Our rotating machinery courses are given in the two terms of the Senior year. The students at that time have in succession recovered from the early shock of the transition from high-school to college, have learned to understand what is meant by "engineering problems," and have acquired valuable concepts and techniques in field theory and circuit analysis courses. Now they can be presented with problems and situations which are realistic and comprehensive, and which they can tackle, without many of the artificialities and over simplifications and instructor's hints which unavoidably accompanied the presentation of problems at earlier levels.

The electromagnetic fields are understood in structures which are tangible and allow for all sorts of measurements; their significance in the process of energy conversion is appreciated. The subject is rich in examples in which formidable situations with time-varying parameters and with non-linearities of all kinds can be reduced, by inventiveness and the use of critically examined simplifying assumptions, to more accessible situations for which significant answers and results can be obtained and discussed. This constitutes a training in mental processes, which the student must certainly employ in professional life, if he is ever concerned with electrodynamic problems, either of conventional mechines, electromagnetic actuators or loudspeakers or any one of the many ingenious regulators and transducer devices of modern systems.

At the same time the study of electric machines offers a good transition from the electromagnetic field problem to the lumped parameter circuit analysis problem. "Equivalent" circuits of suitable kinds can be "invented" by the students, with a clear understanding of their scope, validity and limitations. Thus the study of the dynamic system behavior of the machine in terms of its terminal characteristics can be approached with an understanding reaching beyond the techniques of transfer functions and transforms which can hardly be postulated and used meaningfully without adequate feel for the underlying electrodynamic processes.

In this light we at the Carnegie In-

stitute of Technology have discarded the idea that the subject may just be an optional one. And we have moved away from "content" questions of the kind, "Should we teach the synchronous converter and spend laboratory sessions on it since streetcar substations nowadays use mercury arc rectifiers?" That machine offers an elegant example of a double energy conversion by the use of a common air gap field; we may consider it as a rich source of intelligent questions. Or we may choose to use for the same conceptual purposes some different machine or system. Of course, by proper organization and choice of the problems, a certain breadth of content can be achieved and some conventional technological information can be gathered. Undeniably this is a welcome by-product but it is not the essential aim of the courses.

The Laboratory as an Integral Part of the Course

The laboratory remains an essential educational tool in this kind of approach. Of course, it is no longer regarded as the place in which the student practices hooking up circuits (under rather artificial layout conditions), reading meters and neatly plotting these readings.

In fact we have de-emphasized the "3-variable problem" that seems to constitute the backbone of many laboratory experiments (not in the machinery laboratories only). "Three variables, x, y and z are interrelated (armature voltage, speed and load torque, or terminal voltage, field current and load, or plate voltage, plate current and grid voltage, etc.). Keep x constant, vary y and read z; repeat the run after having given a different value to x and so on. Then repeat the whole procedure two more times by permutation of the variables and then plot and cross plot these families of curves."

A couple of experiments of this kind, performed at some time in the student's career, may be sufficient. They have some value because they give to the student the beginner's thrill of seeing that curves and characteristics he sees in textbooks and catalogs are something real and obtainable by direct experimentation whenever the need for this arises. But enforced repetitions of this trivial kind of assignments without broader purposes is bound to engender lack of interest and curiosity and on the whole constitutes a most inefficient use of the limited time available in the curriculum.

Actually the laboratory is an integral part of the machinery course as it accomplishes two main purposes:

1) It offers abundant opportunities for demonstrations of the electromagnetic fields of the machine under direct, active participation of the students. This we find necessary because many concepts are elusive to the beginner and not adequately meaningful to him from his previous courses. Simple expedients, for instance the use of a few search coils, can clarify essential issues much better than any blackboard description and explanation.

2) It provides a method to be used concurrently with the analytical approach in the solution of problems. This we consider to be the most important point.

Some Examples

Examples of what is meant by all this can be given only in a sketchy and incomplete form here. Every interested teacher is entitled to have a certain number of preferred experiments of his own; the subtle question under discussion is not "which experiment should be performed?" but rather "which is its very purpose?"

For instance, at an early stage in the course the air gap flux density distribution of a d.c. machine is measured by the old gliding-pencil method. That is, voltages between one brush and a movable contact on the commutator are recorded. This can be done at no-load or, with some care, under load conditions. The interprettion of these readings for the assignment at hand involves some less than obvious concepts of time and space integrations. The results can be compared

with predictions from graphical field mapping. Actually the matter of flux density distribution could be avoided at that time in the course and by-passed with the simpler concept of flux per pole. But the latter concept, while adequate to develop standard formulas for the no-load generated voltage of a d.c. machine would be too narrow and indeed crippling for any further purpose. (It may be interesting to point out that this old experiment seems to have been among the first ones to be sacrificed in compromises aiming to salvage standard tests of standard steady-state porformance.)

In the same light the air gap field of a.c. machines is investigated and understood with experiments on the single-phase and 3-phase induction regulators. Again this is done at an early stage as an indispensable introduction to the study of any particular alternating current machine. These investigations are accompanied by problems, analytical and experimental, dealing for instance with the static torque of the same machine with stator and rotor windings variously supplied with direct current. Numerical predictions result from the "Bil" reasoning or from virtual displacement approaches. In fact, concepts of torques and also application of Newton's laws to rotational motion seem to receive a most needed clarification in the Laboratory.

At a later time, the voltages induced in a full-pitch exploring coil on the stator of a 3-phase salient pole machine during a "slip test" are displayed on an oscilloscope and recorded photographically. It is recognized that the fundamental component of that voltage remains nearly unchanged, while the wave forms vary conspicuously throughout the test. This leads to a clear understanding of complex phenomena and factors of design and also to a lasting appreciation of the ingenuity and elegance of two-reaction theories. On the other hand standard tests of overall behavior ("The V-curves have the shape of a V") are found less useful in the same area as they add very little to whatever the student may have grasped before the performance of the assignment.

Incidentally, I remember how in my own experience as a student I managed to understand that a terminal voltage of sort appears at the terminals of a synchronous generator at no-load, and I understood also that the flow of load currents in the armature winding modifies this voltage with some secondary effects because of resistances and a few other semi-obscure phenomena. We did and overdid standard experiments on regulation, drawing vector-diagrams and using all tricks of the trade such as Potier triangles, derived for cases of round rotors and not too meaningfully applied to saturated salient poles, and what not. But the tremendous significance of the armature reaction fields in the process of conversion of energy dawned upon me only years later, when I had been for some time a junior design engineer in industry. (Of course, I may have been a particularly naive fellow).

Two more examples may help to illustrate the point of view.

As soon as the magnetization curve of a d.c. generator is determined by separate excitation, the significance of this information is put to use in a variety of problems, from immediate predictions and checks of self-excitation behavior to studies of the d.c. machine as a power amplifier with various types of feedback. Concepts of time of response, and gain and "figures of merit" are developed (without concealing their limitations) and compared with quite similar concepts arising in other kinds of power amplifiers.

Finally a laboratory problem is described that is usually presented in junior courses dealing with transformers. We have some moving-coil transformers for street lighting series distribution systems. One could study these devices with the "3-variable" approach (the counterweight, the number of light bulbs in series, the current). The students could be led to recognize that this constant output current device keeps the output current more or less constant. But this would be

an uninspiring waste of time. On the other hand the availability of these unusual structures in the laboratory may lead to a number of broader problems, involving study of leakage fields, the prediction and check of forces between coils, and a study of dynamic response to step changes of load and of the subtle question of steady-state stability that arise whenever the load has a capacitive component. Of course, light bulbs are not capacitive, and we are aware that these awkward regulators are being replaced in practice by devices without moving parts. But these factors are irrelevant in any decision to devote time to the study described, in the classroom, in the computation room and in the laboratory.

Coordination

It is obvious that laboratory work thus designed must be carefully coordinated with the other parts of the course. Analytical problems should be chosen in the classroom that lead to the immediate need or convenience of experimentation, conceivably followed by further analysis and also further related experiments. This continuously taxes the ingenuity of the instructor, but, by judicious choices depending on the equipment available, remarkable achievements can be obtained even with limited means. (On the other hand it may be noted that "platoon" systems in which individual groups are required to perform certain "must" experiments in cyclic permutation, out of step with the progress of the course, are of little use. Whenever it is found indispensable to expose students at a certain time to a certain experimentation for which no sufficiently large facilities are available it may be educationally preferable to combine groups or even to convert the assignment to a kind of demonstration performed with the instructor's participation.)

This interlocking of analysis and experimentation is the essence of engineering and deserves to be stressed even at the somewhat embryonic level of undergraduate college education. As laboratory and classroom problems become inter-related it becomes also easier to prevent the well-known evil of laboratory work: The lack of pertinent preparation and the failure of the students to really understand the purpose of the experimentation.

A question can be raised at this point: If machinery courses are intended to be primarily courses on electrodynamics and not on standard technologies is it necessary to have standard machinery laboratories in their customary layout? Can't we achieve the same aims using sub-fractional horsepower machines, on a bench or inexpensive educational "erector" models available on the market or different electromagnetic devices altogether?

Probably we could, to some extent. But small machines and erector models are not too well suited to significant studies at any better than qualitative level. This is so because those simplifying assumptions, that in larger machines allow the beginner to focus attention upon a comparatively limited group of phenomena at the time, often cease being reasonable. The high per-unit resistances and the poor winding distribution are some examples of these unwelcome and confusing difficulties. It is much more difficult to conduct a quantitative, nonsuperficial study of a kitchen clock motor than to evidence and evaluate reluctance torque phenomena in a conventional synchronous machine. Similar reasons may limit, though not necessarily exclude, the use of other electromagnetic devices for the educational purposes outlined at the undergraduate legel. A real advantage of the use of conventional machines in electrodynamic studies is found in the well established possibility to pitch the study at any wanted level progressing as needed, from the most elementary to the most sophisticated approach in a gradual manner.

Conclusions

It appears from all this that the use of the machinery laboratory within the educational aims outlined does not imply the

need for new and extravagant stunts. What is really needed is a continuous, thorough, critical examination of the meaning and worth of the experiments chosen, not in terms of some narrow technological information of non-lasting value, but rather in terms of their contribution to a deepening of basic understanding of the physical laws.

Indeed "basic" and "fundamental" by now are standard words of the educational vocabulary and the considerations just presented may well sound as an unnecessary repetition of truisms. Yet from time to time one wonders how often these words are only accepted and misused to rationalize on anachronistically unchanged attitudes. A nationwide examination, aiming at a search for promising young scientists to be supported with graduate scholarships, was said to have contained, among others, this question: "Of the following 5 methods proposed to calculate alternator regulation (list of names or abbreviations given) which one yields the lowest answer?" Anyone familiar both with the acknowledgedly semi-empirical nature of Test-Code prescriptions and with the huge theoretical difficulties of any reasonably adequate treatment of this problem may wonder whether it is seriously meant in some quarters that our training of young scholars should be directed towards the delivery of memorized pat answers, without even the benefit of references.

This seems to be so completely opposite to the aims we thing should be set in our courses and laboratories that renewed clarification and discussion may not be superfluous, after all.

In the News

The **National Science Foundation** has announced for 1956 approximately forty senior post-doctoral fellowships to individuals planning additional study and research in the life, physical sciences, and closely allied fields. Fellows will be selected on the basis of ability as shown by letters of recommendation, academic records, and other evidence of attainment. The final selection of Fellows will be made by the National Science Foundation. Successful competitors will be announced in March, 1956.

The **Atomic Energy Commission** has made available for the academic year 1956–57 a number of special fellowships in two relatively new fields of scientific endeavor closely related to the atomic energy program: industrial hygiene and radiological physics. The Oak Ridge Institute of Nuclear Studies will administer the fellowships for the Commission.

Thorndike Saville, President of the Engineers' Joint Council and Dean of Engineering at New York University, recently received the **American Society of Mechanical Engineers' 75th Anniversary Medal.** Dean Saville was chosen for the ASME's honor "in appreciation of his friendly cooperation and in recognition of his outstanding leadership in the Engineers' Joint Council and as its President."

Aim for Ames in 1956

Education by Research Training*

By JOHN T. RETTALIATA

President of Illinois Institute of Technology

This discussion of Education by Research Training will be confined, as closely as possible, to the value of research to the student and its consequent effect on the development of future leaders capable of creative thinking for the advancement of learning and human welfare.

Engineering educators have been long aware of the usefulness of research training to the student and have realized it is an essential step toward the development of the mature research worker whose labors explore the paths for mankind's progress. Because of the scope of the subject I have consulted with some of my colleagues engaged in research activities at our institution, and am privileged to have the benefit of their comments.

The subject is timely in this age of science and technology because these pursuits are sustaining our existence. And, research is the life-giving source of new technology. Many of us are concerned that our nation's scientific and technological research depends upon the efforts of less than one per cent of our country's population. Even this small corps generally knows only one facet and one specialism at a time. In the meantime, science is moving out beyond the world of daily, common sense experience into a universe that is stranger perhaps than we can imagine.

The situation places heavy responsibilities upon educational institutions. There is not only a tremendous and growing demand for more graduates to operate the technology but there is a serious need for better-prepared individuals who will advance the frontiers of science and technology. In today's world, persons who can think new and different thoughts, conceive new things and methods, and exercise honest inquiry and judgment are a priceless possession of humanity.

One of education's objectives is to instill in the student an attitude of enlightened appraisal toward society. This is an important objective because if it is neglected we perpetuate a static society. Obviously, society is not static . . . it wasn't, even in the Dark Ages. Civilizations always become more complex. This changes living conditions and moral standards. When there is unquestioned acceptance of everything as it occurs, decadence and destruction of culture are inevitable.

A research worker learns early that he can accept no premise as a valid one until it is proved. His research training is desirable because it educates him to maintain an attitude of intelligent criticism.

Intellectual growth results from the exacting nature of research endeavors. Research expands man's understanding and control of nature as he seeks to uncover new facts, new relations and new principles. To penetrate the unknown, the researcher must understand the known with great thoroughness and clarity.

Adds Interest and Significance

Research is the element which adds interest and significance to an educational program and, as such, is a proper and essential part of all education at the college and university level. It is important, alike, to both undergraduate and graduate

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students. Scientific research will have a lasting effect on the attitude of the student. After being appropriately associated with it he is no longer content with merely attending classes, but rather experiences a creative compulsion to contribute to the advancement of his field of study. This is a worthy characteristic of proper research training.

Further, research training permits the institutions of higher learning to provide students with fundamental principles and techniques which will be applicable to the solution of all problems. The volume of human knowledge has become so vast that the schools and colleges can present only its rudiments. Facts and information which are not quickly used are likely to be forgotten. Since it is not the intention of education to make factual depositories of our students, research training is an effective means to the acquisition and creation of knowledge, the formulation of hypotheses, the evaluation of those hypotheses by experiments and known facts, and the tentative and critical acceptance of solutions.

Another of the important benefits the student may derive from participation in research is the habit of critical evaluation . . . not only of the data which he may accumulate in his own experiments . . . but of conclusions derived from experimental observations and from published records of research performed by others. Evaluation of the published research of others in the same field as the student's own endeavors is most decisive. It teaches the student to become his own severest critic . . . of both his plan for experiment and of his interpretation of the data he may accumulate.

Research experience makes the student aware of the difficulties involved in all experimental procedures. As he learns of the possibilities of obtaining varied results by employing different procedures or a more enlightened approach, he realizes the dangers of pitfalls and the possibilities of manifold interpretations of data. Thus, research has a broadening influence in his education. The research-trained student will question all statements, will differentiate between opinion and fact, because the ever-widening technical approaches to the solution of his experimental problems have enhanced his educational experience.

Research instills in the mind of the student an attitude which provides him with a new perspective in other intellectual pursuits. It emphasizes the fact that the magnitude of our knowledge is dwarfed by truth yet to be discovered. He realizes that most textbooks are out of date by the time they are published, and that many of the research reports in the journals are similarly not current.

Additionally, the research student makes the valuable discovery that some of the principles found in the textbooks and journals are reliable and some are not. He develops a cautious approach. The usefulness of published information is seen in a fresh perspective. He learns to read widely and critically, fitting each new piece of information into the pattern of his previously-tested experience. Literature becomes, as it should, a tentative introduction and only a prologue to his further study and development.

If nothing else, research teaches the student that he must do thinking of his own. He is aware that the advancing front of knowledge possesses a fluidity which makes predictions of all possible generalizations, laws and principles uncertain. He learns that to keep up with the latest ideas and developments he must read widely, engage in conversation with others who are making similar studies, and maintain an inquiring mind.

His experience stimulates curiosity as well as the critical approach. As new ideas develop in his mind he becomes increasingly anxious for every opportunity to explore them and put them to the test of experiment. Thus, research pays off in the educational process. It neutralizes the deadness sometimes associated with textbook teaching and stimulates the student to do creative thinking. Research training presses the student to live and

grow and insures that his work will have new vitality.

Influence of Environment

Having enumerated the value of research training . . . to both the student and the educational process . . . it is appropriate to refer, briefly, to the fact that such training, alone, may not necessarily develop the vital outlook we desire. Researchers learn about pitfalls and the possibilities of obtaining different results by varying the circumstances. We, therefore, must consider the influence of environment on the student's ability to learn.

An environment of creativeness must be the goal of education, especially in the field of engineering. But creativeness must be cultivated by providing the student with the proper climate.

A student gets much of his inspiration for creativeness from his instructors. They, too, must live in a creative atmosphere which derives from constructive research activity. Instructors, engaged in research and consulting activities, can make their lectures alive with reports of their experience gained in the laboratory or industry. They can present advanced knowledge, not yet in the textbook, and by example inspire creativeness and a sense of professionalism.

As a partial digression, let me state that I have no intention or desire to engage in any discussion implying that teaching and research are incompatible, a situation that is sometimes asserted to exist. Certainly the instructor engaged in research has the advantage of bringing freshness to his subject, but since teaching is an art and not a science, it does not follow that he, therefore, possesses any special ability to communicate the import of research findings to his students. Conversely, because he is engaged in research does not mean that he has no interest in teaching and cannot be effective in it.

Similarly, we all know of many excellent teachers, not directly associated with research, who were particularly adept at elucidation. To be most effective, however, these instructors must keep their lectures current through a continual pursual of the literature in their fields. Obviously, this method does not possess the immediacy of direct research but can be satisfactory if conscientiously pursued.

When the instructor can be helpful and provide the right climate, the student can be inspired by research assignments. This is possible when the student senses that his advisor is deeply interested in research and in contributing to the advancement of knowledge in his field. The instructor's contribution may be only the reviewing and evaluating of articles for publication in the scientific and engineering journals . . . but it must be an indication that he is doing his part in the total effort of the world's scientists and research engineers. When there is evidence that the work of the laboratory is important and is respected by competent workers elsewhere, the student will develop a desire to contribute too.

This suggests a further feature about education that is provided through research training. Such training contributes to the development of sound character. It develops men of initiative and self-reliance, who are willing to accept responsibility and who will be creative and constructive future workers in their field of interest.

Such an objective is highly desirable. Research training can further such a goal. It can create an attitude that proves contagious. The attitude can be transmitted from the teacher to the student, or better yet, from student to student.

They, who are anxious for the spread of such an attitude, may appreciate research training for its effectiveness in developing good students and better citizens. An entire student body may be upgraded by admitting selected students to the research laboratories, by encouraging them in satisfying achievements, and by depending upon them to grasp a new outlook on education that they will pass along to other students. When more students complete research problems that represent a contribution, even though

small, to the advance of knowledge they will foster an increased thirst for education among their classmates.

The increased interest and imagination of students can be stimulated by aiding them in the realization that there remain many unsolved problems which form the basis of current research activity. Undergraduate courses should be continuously revised to permit the introduction of recent research results. We must guard the undergraduate from assuming that human knowledge is a completely developed and organized affair. Through research training we can demonstrate that the present knowledge is tentative and that it is being constantly revised and extended by research publications and review articles each year.

Guidance Difficult

Admittedly, such guidance for students is difficult, especially if they are free to choose their own problems. The research advisor must be careful to give the student freedom but, at the same time, attempt to guide the selection of problems which can be accommodated by resources available and which, preferably, have an opportunity for solution.

Even if it is the judgment of the advisor that the chances are small for a solution of the problem which a student selects, the student should be permitted to proceed if he is especially desirous to do so. Fortunately, under such circumstances, as with most types of research, unexpected problems and especially interesting new developments may be uncovered that will counterbalance the lack of a solution to the original undertaking.

Research training reaches its greatest effectiveness in the educational process on the graduate level because the student is more mature and, generally, is of above average ability. Further, he usually has demonstrated a desire for increased knowledge.

While the value of research is recognized, the interjection of a precautionary note might not be amiss. In our great enthusiasm for research as a tool used in the educational process, let us not create an illusion that research is a cure-all for the world's multitude of problems and troubles, nor lose sight of the fact that education by research training is essentially a means to assist the university or college achieve its proper goal of helping man know and understand more.

It is unfortunate that respect for research is more easily instilled than understanding. There are some segments of the public which tend to give unwarranted weight to the pronouncements of the research scientist in fields other than that on which he is expert. Among true scientists there are no final authorities. They know it is not the researcher but his evidence and his logic that count.

It is possible for a society to become too much absorbed in methods, even when they are scientific methods which lead to great technological progress. Education by research training does not necessarily equip men and women to set up ultimate values for society. It does prepare them to test, if they will, the values which evolve in the changing culture, to reject those which can be shown to be unworthy on the basis of man's knowledge and experience, to propose hypotheses which in their turn are tested, and thus to further the maintenance of an intelligent, critical attitude toward society.

Since research is a necessary and proper part of higher education it should be encouraged. It is the function of a university to create new knowledge, through basic research, as well as to disseminate it, through teaching. And the research activities of universities have been increasing at a rapid rate. Unfortunately, however, the emphasis has not been on basic research but rather on the applied, or hardware, type of project. This is understandable in a period of war where national security is involved and weapons research is vital. But the inventory of basic scientific discovery is rapidly being depleted by the drain of technological progress. It is important that the stockpile be replenished or we may become a

nation devoid of the means for further achievement.

Reasonable Relationship Important

However, while the desirability of fundamental research should be recognized, it should not be concluded that applied research is out of place in an academic institution. The university should also be concerned with the practical application of the new knowledge which it creates. By so doing its tremendous intellectual capacity can participate in the solution of society's problems. The important thing is to maintain a reasonable relationship between the two types of research.

In my opinion effective training can be accomplished in either basic or applied research, sponsored or unsponsored. Each kind has something of value to offer the student where the research objectives are compatible with the institution's program. The fact that some outside agency is supplying the funds to support a project does not mean necessarily that it is not a suitable matter for investigation by an academic institution.

In research training it would seem particularly appropriate that the student have some association with applied research. This is the kind of research predominant in industry, and since most engineering graduates are employed by industry, proper preparation of the student would involve some familiarity with this sort of endeavor.

The emphasis of the academic research program, however, should be on basic aspects because research which favors certain fields of knowledge at the expense of others, in which the goals are too limited, or which is tied to too strict a time schedule can tend to divert scholars in the colleges and universities from research which extends the boundaries of knowledge. The student who only follows a problem as outlined in detail will not acquire the proper attitude or aptitudes toward research. In such case he will gain experience only in the execution of the experiment, and to a certain extent in the analysis of the data, as the advisor usually assists in the evaluation to derive the fullest measure of information for the benefit of a review panel. If the purpose of education by research training is to increase knowledge and understanding, it is important that the research undertaken is devoted primarily to achieving that mission.

Conclusion

Without doubt, research properly conceived and conducted is an essential part of the college and university educational process. It yields benefits to both the institution and the student. It develops character, self-reliance, initiative, and enthusiasm. It results in a changed attitude of the student toward his studies, and enhances the value of his courses and of his use of the scientific literature.

In the years ahead, to do a truly effective educational job, increased emphasis must be placed on this kind of research. Accomplishment will be difficult, however, principally for financial reasons. Higher education, both public and private, now hard-pressed for funds, will experience a continuing fiscal struggle. We should not despair, however, but rather gain courage from the conviction that the mission in which we are engaged is worthwhile. Because of this we are confident that an understanding public will support it.

The Thermodynamic Method of Attack*

By A. K. OPPENHEIM

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Introduction

When I submitted the title of this paper, I was asked whether it is *exact.* I replied that it is, although I knew that it was not *complete,* since I had difficulties in defining the target for the attack and, consequently, left it unspecified. The method deals of course with engineering systems or engineering problems, but in my opinion, its main virtue is in *defining the system and specifying the problem.*

The first question, one may ask, is whether there exists such a thing as a "thermodynamic method"? In fact, I was not aware of it some twenty years ago when I started my studies of this subject. And one cannot find any evidence of a distinct method in the old classics which treat thermodynamics either as a branch of physics or chemistry (Planck (1), Guggenheim (2), Lewis and Randall (3)) or engineering (Goodenough (4), Schüle (5), Stodola (6), Barnard, Ellenwood and Hirschfeld (7)), or of philosophy (Planck (8), Bridgman (9)). The second logical question which suggests itself is then that even if such a method existed, whether we should teach it to our students or whether it would not be better to leave it for themselves to discover?

In the present dispute on these questions I would like to defend the positive. I shall, however, limit the scope of my proposition. I do not know whether the method should be described in our texts and, for that matter, I doubt whether it is at all possible to present it adequately in a book. But I am quite sure that it should be *emphasized* in our undergraduate courses known as Engineering Thermodynamics for Mechanical Engineers. In our College, as in many others, such a course is offered at the junior level in the mechanical engineering department. In my future remarks I shall therefore have this particular course in mind.

Why a Thermodynamic Method?

The necessity for emphasizing a method in an undergraduate course stems from my belief in the importance of adopting a unified point of view for presentation of any subject matter at this level. Irrespective of whether we favor approaching a subject from the general to the particular or from the particular to the general, the synthesis, in my opinion, is the key and the objective of university instruction.

When our students are first confronted with the problem of learning something about thermodynamics, they have been already acquainted with a number of engineering subjects such as graphics, manufacturing processes, measurement, engineering materials, and statics. They also have had a few courses in mathematics, physics, and chemistry. Introducing then a new subject at this stage, one should realize what most distinguishes thermodynamics from other branches of physics or engineering. The feature which always appealed most to me is that it provides a prescription on how to talk intelligently about things we do not know anything about. This notion is of course

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associated with the fact that in our undergraduate courses we emphasize the macroscopic point of view (as it has been indeed advocated at a similar discourse of this Society by Keenan (10) and Kaye (11) some time ago).

The approach to engineering analysis from a macroscopic point of view constitutes therefore the salient feature of the method.

What is the Method?

More specifically, the method consists of the proper treatment and arrangement of information on physical properties leading to the "engineering" definition of the system and formulation of the problem for the "thermodynamic" analysis.

At this time I must stress the fact that I am not trying to present anything original. In fact, I am sure, the method is well-known to all of you. Its application to thermodynamics was developed mostly by the M.I.T. group of Keenan. It was propounded by Boelter and his associates at our University, London and his group at Stanford University, and advocated by many others. It is described in many texts on engineering thermodynamics and related subjects such as those of Keenan (12), Lichty (13), Obert (14), Mooney (15), Shapiro (16) and Sweigert and Goglia (17). It is so fundamental and general in scope that, one may say, it is more characteristic of the whole class of problems of performance analyses of engineering systems. In this respect it is therefore closely associated with the design problem (the latter often involves a series of performance analyses; one being the inverse of the other) and, consequently, could be regarded as the most characteristic of the modern engineering practice.

What I would like to defend here is the viewpoint that it should be *properly introduced with a good deal of emphasis* at the junior course of engineering thermodynamics. The reason why this course is most appropriate for this purpose is the fact that it deals primarily with the most characteristic feature of a macroscopic analysis, namely, with the conservation principle.

In an engineering course one would like to, and should, tie-in the analysis with the engineering language: graphics. It is quite proper, therefore, to present the principle in this case by the use of a system diagram. The diagram should be considered much superior to the equation, and it is to be deplored that in so many texts and expositions of the fundamental features of thermodynamics the equations are often emphasized at the expense of the diagram (e.g. the so-called "general energy equation"). The student is thus sometimes led to the conclusion that, in order to know a subject, it is sufficient to know the equations, understand the symbols, and that the only effort needed to solve a problem is to substitute values into the algebraic formulas pulled out from the book or lecture notes. But even those who understand the importance of the diagram often skip the step between the engineering system and its diagrammatic representation.

What makes a collection of things an engineering system? The answer is obvious. A sufficient understanding so that its salient features could be represented *diagramatically* and its *boundaries* prescribed. What is then the most important aspect of the translation between the physical world and its engineering description which then forms the basis for the analysis? Obviously, the introduction of *idealizations* (or the so-called assumptions). This in reality can never be omitted, but in the instructions is often neglected. For the purpose of a given analysis we must specify that an element is rigid, a wall is impermeable, a substance is homogeneous. The results of the analysis represent then only the consequences of these idealizations and do not furnish a complete solution to an "engineering problem." In fact, I heard it stated many times, there is no such thing as a single solution to an engineering problem. But a properly specified system with a full set of idealizations

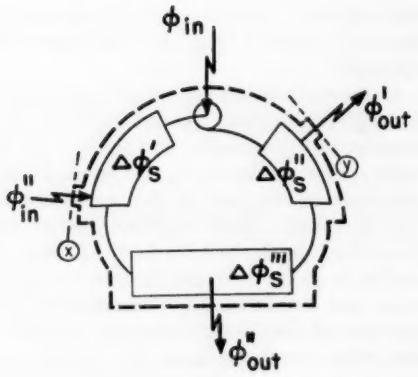


FIG. 1.

must lead to a single solution. Otherwise, the idealizations are not complete.

If it is agreed that these aspects should be properly emphasized, the last question is: How to do it?

How I Present the Method

One way of dealing with this situation is by means of the following method which I have used over a number of years, but which by no means is perfect and, of course, is open for criticism.

Utilizing the First Law as the excuse and general background for the topic, I present first the general features of applying a conservation principle. I use for illustation a variety of classes for which the existence of the principle can be postulated, such as money, mass, and (finally) energy. I break the procedure into three steps (Fig. 1):

Step 1. Define the system graphically and prescribe its boundaries.*

Step 2. Define (and indicate on the diagram) those elements of the class which cross system boundaries and those which are stored. (Note the use of zigzag arrows to denote scalar quantities.)

Step 3. Apply the conservation principle which, with the help of the diagram, can be now stated as an equation:

$$\Sigma\Phi_{in} = \Sigma\Phi_{out} + \Sigma\Delta\Phi_{stored}$$

for same τ_0 and $\Delta\tau$

In the first step I describe the introduction of idealizations concerned with the system, such as the permeability of walls (with respect to value, mass or heat transfer as the case may be), the rigidity of the elements; and the relationship between the boundaries and the available information on one side, and the results of the analysis of the other. I emphasize then that, consequently, the boundaries should be determined on the basis of a careful *design* and I demonstrate how, by their proper prescription, the same physical system may be considered either as an open or a closed one, depending on whether the mass is allowed to cross system boundaries or not.

In the second step I emphasize the introduction of the idealizations concerned with the properties of the working substance; the relationship between their state when they cross system boundaries and their equilibrium state and the requirements associated with assigning values to their magnitudes which, as can be demonstrated, is always relative and involves therefore the use of the concept of datum. In the case of energies the usefulness becomes apparent of a distinction between those energies which can exist only when crossing system boundaries, such as work, heat and flow work, and those which can be only associated with mass, such as internal energy, potential energy, etc.

The last step involves only an accounting procedure. I emphasize the obvious

* The term "boundaries" is used here in the sense of the so-called "control surface" (see, e.g., Shapiro (16) or "Classical Thermodynamics" by J. H. Keenan, Notes for the Rumford Summer School of Thermodynamics, Massachusetts Institute of Technology, 1953). The boundaries define any identifiable volume of space. They may move and matter may cross them at one or more places. For the sake of convenience, however, those parts of the boundaries through which matter crosses should be considered fixed with respect to the observer.

fact that in order for the equality sign to be true, all the quantities must refer to the same initial time τ_0 and the same time interval $\Delta\tau$. This allows me to elucidate on the fact that the same physical system may be considered as a steady or non-steady flow system, depending on the selection of $\Delta\tau$. If $\Sigma\Delta\Phi_{stored}$ is zero the system is steady. In the case of mass this leads to the concept of the steady mass flow system; in the case of energy to the "steady energy" flow system. If, by a proper prescription of the boundaries, in both space and time, such a condition can be fulfilled, these notions may be often successfully exploited in the analysis.

At this time I like to inject some doubt into the students' minds as to whether our accounting has been complete or not. This stimulating, but often frustrating question leaves then a convenient opening for the future discussions of the First and Second Laws, the introduction of state functions, their relationships, state diagram, the concept of available energy, equilibrium, and even rate processes; in fact, the whole of macroscopic and even microscopic thermodynamics.

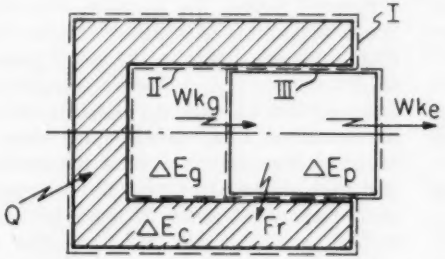
It should be noted that the method is based on the use of the diagram. As a logical consequence then of this feature, the well-known *sign convention* concerned with the direction of heat and work transfer *should be dispensed with from an "engineering" exposition of thermodynamics.* The use of a system diagram is, of course, well-known in engineering analysis (e.g. the free-body diagram of mechanics). However, for the purpose of a thermodynamic analysis its design and proper specification involve the consideration of more concepts than in any other case and, in my opinion, this fact should be clearly reflected in our instructions.

Examples

To illustrate the application of the method I shall use two examples: an elementary one and one more advanced.

The elementary example is taken from Obert's text (15), problem 6, page 46:

A piston-cylinder arrangement has a gas in the cylinder space. During a constant-pressure expansion to a larger volume, the work effects for the gas are 1.60 Btu, the heat added to the gas cylinder arrangement was 3.17 Btu, and the friction between the piston and cylinder wall amounted to 0.25 Btu. Determine the external useful work done by the process,



Given:

$Wk_g = 1.60$ Btu

$Q = 3.17$ Btu

$Fr = 0.25$ Btu

Find:

Wk_e

$\Delta E = \Delta E_g + \Delta E_c + \Delta E_p$

Syst. III: $Wk_e = Wk_g - Fr = 1.35$ Btu $\quad \Delta E_p = 0$

Syst. I: $Q = \Delta E + Wk_e$ $\quad \Delta E = \Delta E_g + \Delta E_c = 1.82$ Btu

FIG. 2.

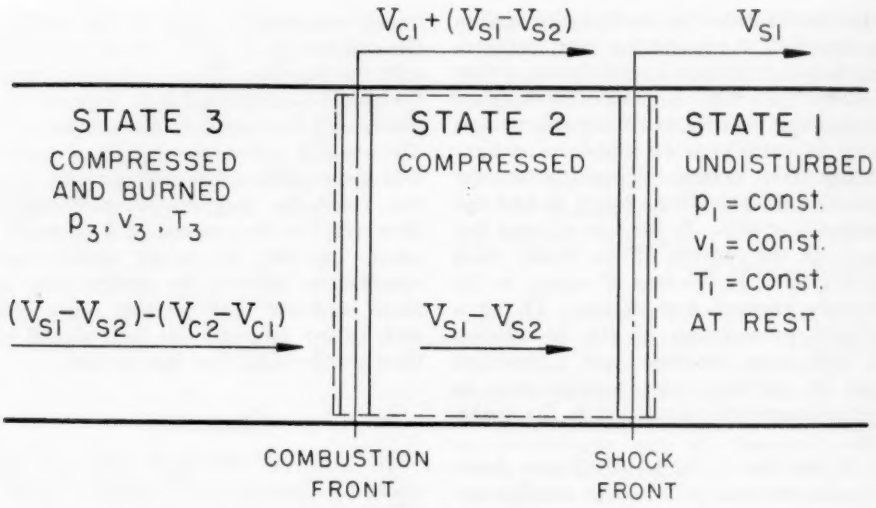


FIG. 3.

and the change in internal energy of the entire apparatus (gas, cylinder, piston).

As demonstrated in Figure 2, one must make a distinction between at least three systems for this simple problem. They are defined on the diagrams by boundaries I, II, III. The boundary between systems II and III is necessary because Wk_g is an energy term which can exist only while crossing a boundary. The distinction between systems III and I is needed to provide boundary for the friction term Fr. The problem is solved by applying the conservation principle to systems III and I. It should be noted that for system II the problem is undefined since not all the energy terms which cross its boundaries are specified.

The more advanced example may be derived from my work on the development and stability of detonation (18). The analysis is based on the notion that prior to the establishment of detonation, the system consists of, at least, a shock front and, following it, a combustion front. The idealized combustion system is presented schematically on a system diagram, Figure 3. The system is unsteady in both mass and state. However, the problem can be fully analyzed as a combination of two steady flow systems, namely that of the shock front and of the combustion front. According to my definition, both can be considered as steady since neither mass nor energy can be stored in such wave front systems. This, in fact, was the most powerful concept which allowed me to answer, in my opinion quite satisfactorily, such a question as: What are the minimum necessary requirements for the development and stability of detonation in a pipe? To my surprise I found, for instance, that both fronts must move at a higher velocity than their final one prior to the establishment of detonation (i.e. when the combustion front catches up with the shock front and the so-called Chapman-Jouquet state is achieved immediately behind the system) and that at the same time the intermediate pressure at state 2 must be much higher than the maximum pressure developed during the fully established detonation. Both these facts were later corroborated by experimental evidence.

Summary

In concluding I would like to stress that:

1. In our undergraduate instructions we should always attempt to present the

subject matter from a unified point of view, even at the expense of the scope.

2. In thermodynamics, this point of view should be associated with the proper definition of the system and its boundaries, both in space and in time.

3. Although the most useful illustration in thermodynamics is provided by the application of the first law, the method leading to the proper definition of the system and the formulation of the problem should be extended to the application of a conservation principle in general, and that of mass in particular (the exposition of the latter should precede the discussion of the first law) and it should be extended to the discussions of the second law and, in fact, used as a common denominator in presenting any topic especially in the junior course on this subject.

Acknowledgment

The ideas presented in this paper have been developed over a number of years of active association with both my students and colleagues. I would like to express my gratitude to all of them for helping me to formulate these ideas and especially to Professors A. L. London and R. A. Seban for many helpful discussions and suggestions.

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The Value of Research to the Education Program*

By J. C. WARNER

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My subject is one that has had much attention in the past and will continue to have in the years to come. It is a challenging subject because in some quarters it is believed that engineering faculties are not as research minded as they ought to be. As evidence, it was reported in the JOURNAL of this society as recently as last year that in about one-third of the institutions with ECPD accredited curricula, the administration gives less than moderate support to staff research, and in 10% was unfavorable to it.

Research as one of the primary goals of an institution of higher learning needs no defense; institutions worthy of the name have always felt an obligation to extend man's knowledge as well as to disseminate it. However, in addition to its significance in its own right, research stands in close relationship to education. It is my purpose today to examine carefully the relationship between research and education to understand it better and to see how it may be utilized to the fullest advantage of both.

I propose to consider in turn research in relation to the student, in relation to the faculty, and in relation to the curriculum.

As in any systematic discussion it is well to begin by defining the scope of the problem. I shall deal with professional education in engineering and science, the kind of education that aims to help the student learn to become not only a competent professional man but also a good citizen and one whose life is enriched by an understanding and an appreciation of our culture. Education to this end is one in which the student is helped to learn basic principles and the ability to apply them with well-ordered, analytical thinking to the problems he will meet as a professional man, as a citizen, and as a person. At the time his formal education is finished he is, in only a limited sense, a professional man. More realistically, the new graduate is a novice, with much to learn; indeed, in terms of the highest professional standards, he must go on learning all his life if he is to realize the attainment of which he is capable. Thus, an essential attribute of the education program which I am considering is that it prepares the graduate to go on learning and growing professionally on his own initiative through his whole life. Moreover, I am considering the *full* education program in engineering and science, which for many, perhaps most of the ablest students, involves graduate as well as undergraduate education.

Relation to the Student

Let us think first of research in relation to the student. How is the student helped to a genuine understanding of fundamental principles and the ability to apply them competently in problems which are new to him? I like Dr. Joel Hildebrand's way of answering this question in his remark that "ability to do something difficult is developed not just by hearing it expounded but by first-hand effort and practice. The role of the learner must be an active one. . . .

* Presented at the ECRC General Session, Annual Meeting of ASEE, Penn State University, June 22, 1955.

This principle is well understood in the realm of physical education, where muscular control is developed by performance, with repetition directed towards ever higher levels of difficulty and skill, and only incidentally by lectures and demonstrations. Athletes, including amateurs, are developed on the field, not on the bleachers." In our kind of education the engineering and science student is helped to an understanding of fundamental principles and to an ability to apply them professionally to new problems by using such principles again and again in problems that have elements of newness to him. The student should begin solving this kind of problem in his freshman year when it must be relatively simple; in later years problems become longer and take on the nature of projects; in the senior and graduate years they become theses. At all stages they have elements of research as far as the student is concerned; in the last stages they also are research from the standpoint of the profession.

Indeed, the high point, the focus of doctoral work, is on research, and this is in part for the reason that the scientist- or engineer-to-be does not really understand the basic principles in his field until he is able to apply them with competence and scholarly style to a problem of the length, depth, and significance associated with the doctoral dissertation. To the student, research is a means of learning and of demonstrating the depth of his understanding.

The principles that the engineering student uses in problem-solving are usually those of science; the method also involves engineering art as well. I am sure that the educational process is strengthened when engineering and science departments are closely knit together, as they are in a single college at my institution.

Research also serves the student's education in another way, by helping him learn how to go on learning. A good research problem usually carries the student out of his narrow field of specialization into areas that are quite new to him, where he has to learn to deal with situations without the benefit of organized courses. For example, one of my Ph.D. candidates in chemistry found that his research required him to measure the dielectric constant of slightly conducting solutions, and then, to advance his own problem in chemistry, he had to acquire competence in measurement techniques at radio frequencies. Before the problem was completed, I, too, had to become familiar with high frequency phenomena. In the same way a research problem in metallurgy required the use of high speed amplifiers and oscillographs. Doctor's theses in civil, electrical, and mechanical engineering often require the candidate to obtain more than an elementary understanding of the chemistry and metallurgy of the materials involved. And it is a commonplace that analytical research in engineering is based upon applied mathematics. Hence, when the student researcher has to acquire or extend his working knowledge in another field, he learns how to go on learning for himself and with a motivation that is not surpassed by any other technique of education.

Thus, while research is often considered to have a narrowing influence because it usually is concentrated upon a specific problem, I believe that research of the kind that should be undertaken in institutions of learning is more often an influence of the opposite kind. It helps to broaden the researcher because in this day of overlapping fields he has to learn and use principles, knowledge, and methods which have been developed in areas other than his own.

Relation to the Faculty

Research is equally important in relation to faculty. The good teacher is more than a competent practitioner of the engineering and science that is known today. He is intellectually curious and this leads him to be a student himself, one who is always seeking a broader and more profound understanding of his own field

and its relationship to other fields. In other words he is a researcher. He is eager to discover, impart, and defend new conceptions, new principles. By his research activity he keeps alive, keeps his viewpoint fresh, improves his perspective, and renews his enthusiasm for his subject.

In my own experience, for example, I have found relatively little enthusiasm for teaching the second law of thermodynamics, enthusiasm that motivates the student to a genuine understanding of the law, unless the teacher himself is making active use of it. And on the other hand one of my colleagues who is doing so in his researches is known for his clear, penetrating expositions of the law to his students. I will grant that there may be exceptions: really good teachers who do no research, and good researchers who are not good teachers, but I think they are relatively few. Think, for example, of the teachers you know who are somewhat less than mediocre in the classroom. Are they generally enthusiastic, successful researchers? I doubt it.

Moreover, there is nothing better to sharpen the teacher's own understanding of basic principles than having to defend his use of them to a reviewer of his paper, or to defend his results in a discussion with a peer who is critical.

It is a truism that a university is fundamentally a community of scholars, the faculty and student body. If an institution is to attain distinction it will be through the attainments of its faculty and the influence the faculty have on the students. Thus, a faculty of distinction is of first importance. Among the requisites for attracting and holding outstanding teachers, none is more vital than a scholarly environment, the opportunity to be closely associated with other scholars; this means significant, fundamental research. Thus, to keep a good faculty, as well as to keep a faculty alive, research is absolutely necessary.

The related fact that a top-ranking faculty brings distinction to an institution directly through its researches needs no elaboration.

If research is to be a real influence on faculty, it must be carried on by faculty themselves. Merely having research and teaching under the same roof does not necessarily mean that the one influences the other. Indeed, this is as false as the notion that by putting a book under the pillow at night one can absorb its contents painlessly. Research which is to have influence must be carried on by the teaching faculty, and this leads to a very real problem of balance. On the one hand research can have little influence on teaching if the professor is loaded with teaching and committee assignments to the point where he has little or no time available to engage in research. On the other hand if he is so engrossed in research that he undertakes scarcely any teaching, or, what may be more to the point, if he cannot put careful thought and planning into his teaching, again his research can have little influence on teaching.

Balance is required, and I suggest that there is an attainable, desirable kind of balance in which the mature professor actively participates in three kinds of activities: undergraduate teaching, graduate teaching, and research. Each kind of activity should be limited in extent so that ideally they can all be carried on in any one semester. If this leads to a total load that is too great, or one that is otherwise impractical, the pattern can be varied with undergraduate teaching in one semester, graduate teaching in another, and with varying emphasis on research.

Influence on the Curriculum

Now, let us consider how research may influence the curriculum. One way, perhaps the most direct one, is in facilitating the addition of new material. A professor carries on research in the area of his interest and helps to advance it. In doing so he becames familiar with what is really important in the new knowledge that is being discovered and brings this material into courses, usually in the first instance, at graduate level.

More often than not, the new material eventually finds its way into the undergraduate curricula. Current examples include solid state science and nuclear science, and I am sure that you all know other instances of this sequence: research, then graduate instruction, and finally undergraduate instruction.

Another way that research influences courses and curricula is in the selection of topics and relative emphasis given to them. In the years that science and engineering have been developing, many, many facts, laws, and principles have been discovered. Certainly not all of them can be or should be learned by the student. How does the educator choose among them? It is clear, certainly in the fields of engineering and science, that material is of importance according to whether it is basic and general, whether it applies in many situations instead of only in a few specialized ones. The teacher who is doing research is in a particularly strong position to know what is fundamental and worth emphasizing. To the extent that the principle is useful in extending knowledge, in solving new problems, it is a principle that certainly should be learned and understood by students. On the other hand, if it is a specialized application out at the end of a development instead of being suitable for the beginning of one, its urgency in education well may be questioned. Indeed, I think it is possible to look at a text book and tell by the choice of material and by the topics given emphasis whether the author is carrying on research and using general principles or whether he is merely a collector and retailer of information.

In what has preceded we have seen how research can contribute to the education of the student, to the quality of the faculty, and to the vigor of the curriculum. What kind of research should be carried on if the greatest useful influences are to be achieved? It seems clear that the research must be basic, must be pointed towards understanding with generality and with precision, in engineering as well as in science. The development of gadgets and hardware for their own sake is not a suitable goal. At a meeting of this same group a year ago President DuBridge of Caltech discussed the goals of research. He gave three good rules pertaining to research in a college of engineering:

1) Maintain a close tie with the basic sciences;

2) Stick to fundamentals; and

3) Be sure that the goals of sponsored and unsponsored research are the same.

Research that conforms to these rules is not only the kind of research that is needed to extend the knowledge of mankind. It is also the kind of research that makes the greatest contributions to an educational program in the ways that I have outlined.

The dangers inherent in contract research have been discussed by many educators: the possible loss of the researcher's independence or part of it; the submergence of teaching in an ocean of research; the financial dependence of an institution on contracts; the throttling of dissemination by security classification—and so on. An institution that is genuinely interested in education will do well to consider these dangers carefully in the light of its educational purpose. However, contract research properly controlled can be a tremendous asset.

Summary

In summary, research has a very important place in the education program. In order to contribute the greatest value to education, (1) it must be carried on by the teaching faculty and by the students, (2) it must be fundamental in character, (3) it must be maintained in appropriate balance with education and other activities.

Evaluation of Engineering Education*

By JOHN K. WOLFE

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Following receipt of the interim report of the ASEE Committee on evaluation of engineering education, the General Electric Company circulated copies of this interim report to various units of the Company and to electric utility executives for comment. My remarks are in a large part compiled from the approximately one hundred replies which have been received. About sixty of these replies came from within the General Electric Company, principally from persons in the engineering function, and the other forty have been received from electrical utility executives. There was unanimous agreement that the principles embodied in this report represent a marked advance in engineering education.

The remarks here are intended to supplement the report rather than criticize. Some areas where we feel that special consideration is needed will be brought up and problems in these areas defined.

General Comments

The most frequently mentioned comment among the engineers surveyed was that one of the greatest shortcomings of the young engineer was the inability to express himself effectively. In light of this comment it is particularly gratifying to see the emphasis which your committee has placed on this matter. Your mention of the facility in expression both written and oral as a professional necessity puts this in both a utilitarian and humanistic aspect. Although your report lists this as a category of humanistic and social studies, our indication of comments from our engineers places the need of better expression above the social study in importance.

General Van Fleet, when asked to comment on his undergraduate impressions of President Eisenhower, emphasized Student Eisenhower's interest in English, resulting in the best ability of expression in his West Point graduating class. As well as giving the engineer instruction in proper English usage and grammar, we must impress him that his future, even in engineering, is closely related to his ability to express himself.

A deficiency of human relations understanding in new graduates has also been noted by our engineers. College engineering education like all other genuine education is of course practical. It is preparation. Its underlying principle is very simple. Young people are to be called upon later to carry on many activities. The purpose of the preparation is to bring it about so that those activities will be done better than they would have been if the preparation had not been given. School and college are both to be judged by practical standards.

From still another point of view, let us protest against the externalism of our teaching in order to get a socially adjusted individual. We teach too much about the machinery of life and far too little about life itself. We teach too much about the things which may be done and too little about what they are done for. As a people we have immense admiration for a man who builds a great library and profound disdain for a man who sits down quietly in the library to read a book, but what is he doing may

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we ask or what use is the reading of a book? What will it enable him to do? If one answers that he reads because reading a good book is a good human experience and that therefore it may be done not for the sake of something else, but for its own sake, practical men are sometimes mystified, but again let us protest that if reading is not good then the building of a library was not good and our benefactor is not good and nothing has been accomplished at all that he has given and done.

Our Company is in full agreement with your report in its recommendations that an engineering graduate should be educated, not merely trained, since upon completion of his undergraduate training, an engineer is merely beginning to learn. Colleges should therefore concentrate on providing the engineer with a broad base of training. This means a fundamental understanding of basic sciences and a humanities training that is closely coupled with the engineering training.

Creative Ability

Some persons to whom we sent the report on evaluation of engineering education felt that some mention should be made and something done to develop latent creative abilities of students. This is particularly needed in the better students and many of our people feel that we are tending to spend more time with the poor student in relation to the exceptional student and that if we did spend the same proportionate amount of time on the exceptional or better student then the overall result would be better. In reality we know less than we should about how the creative person functions in both science and in engineering but this is a problem which ought to deserve good study. All we really have been able to do so far is to provide an atmosphere in which a person can be creative. Many in the education field feel that the development of creative abilities stems all the way back to the students very early years and is involved primarily in developing a good curiosity.

Social Responsibilities

In our free competitive enterprise system, the product is "the thing." It is the very core of our whole economic and social structure. When a product is evolved which serves a useful purpose, it obviously contributes to our social and economic structure. The individual business venture in the free competitive enterprise system rises or falls depending upon its ability to furnish a product or service which the people desire and for which they are willing to spend some of their income. Thus it follows that the engineer and his contribution lie at the focal point of our social and economic progress.

A broad concept of engineering is in making useful to man the properties of matter and the sources of power in nature. There are many noble ideas to which a man may dedicate himself in this modern age, but I submit that this one of the engineer is among the finest. What greater practical service can a man perform for his fellows than to apply his specialized knowledge to the production of new and improved structures, machines, and manufactured products. The broader and more fundamental concept of the function of engineering is too easily overlooked in this technical age. We are so concerned with engineering in the specific that we are prone to forget its broader spiritual aspects.

A more subjective view point of engineering is found in the profession's own concept of its function. In the canons of ethics for the engineers adopted by the Engineers Council for Professional Development we are told that it is the engineer's duty "to interest himself in public welfare and to be ready to apply his special knowledge for the benefit of mankind." In a model adopted by the organization, we find the following, "When needed, my skill and knowledge shall be given without reservation for the public good. Special capacities bring the obligation to use them well in the service

of humanity and I accept the challenge that this implies."

The Better Student

As I mentioned somewhat earlier, some of our people feel that a greater differentiation of students should be made on the basis of ability and more opportunities should be provided for the gifted student to perform to the limit of his abilities. We are interested in the segment of the class which is capable of accelerated study. While it is true many of these people will go on to graduate school both in engineering and in science we feel that this should be encouraged and the depth of the engineer's training should be made as wide and as basic as possible.

More attention should be paid to reading and study habits. It is true that this begins often in secondary schools and even in primary schools. The student who is taught to read rapidly and comprehensively can double his productivity. We have often had the sad experience of people coming to work with us who read very slowly and really do not know how to study. This number is in the minority and we are happy that the unfortunate situation is definitely on the improvement.

The methods of attack utilized in solving overall engineering problems should be emphasized. Many times the particular engineer in a narrow field will know the specific methods of attacking problems in his own special field without knowing those overall principles which are used in all phases of engineering and science. This applies to the science field as well, since the integration of the engineer and the scientist is becoming more and more important in all of our operations.

We are in full agreement with your report that closer collaboration is needed between the science departments, physics, engineering, and mathematics. The studies of mathematics and engineering are particularly important and should be well co-ordinated so that the student studying engineering can make full use of all the mathematical tools available. Some schools have felt that the students who are not science majors should take only a part of the regular chemistry, physics, or mathematics courses, and in trying to cut down the time some watered-down courses in science have resulted. We object to a narrowing of the science curriculum in these simplified courses since we feel the engineers need thorough and basic science courses. Some comment has been made that the high mortality rates in these science courses decrease the number of graduate engineers available. We do not feel that this is necessarily the case. If a good science course is given and is presented well, we believe that the number of good engineers resulting from such courses will be essentially unchanged.

Although there is a possibility that engineering laboratory time, as well as science laboratory time, can be reduced in the curriculum, we should be careful not to eliminate laboratories for teaching basic experimental methods. Laboratories can be used as problem-solving experiences since they permit practical application of the theories. Many times the instructor will do laboratory demonstrations before the class or student rather than to let the student do his own demonstration and his own write up. The personal experience of the laboratory is much to be preferred over the laboratory demonstration.

Some of our people have pointed out that with the introduction of some of the proposed curriculum changes in this report, a motivation of the student may become a problem since the student will receive less actual engineering education early in his college training.

College Curriculum

One of the greatest controversies in the comments received from our people on this report was in this area and centered on the four versus five-year curriculum. In our own survey, a slight majority of our people favored the four year program, feeling that additional college

training was not always necessary and that widespread adoption of the five year course was unnecessary and would reduce the number of graduates available.

As mentioned earlier in this report, many of our people felt that the student should be taught effective presentation, both oral and written. In this connection an attempt should be made to integrate the study of English Composition with technical report writing. As many of your are aware, the writing of technical reports is a most important engineering function. Even though an engineer does an excellent technical job, if he cannot write a lucid report or make an effective oral presentation, little will be gained from this technical job. At a recent conference of professors of chemistry and chemical engineering, Dr. Joel Hildebrand of the University of California at Berkeley was asked the question as to how long he thought it would take to teach a scientist or an engineer good English, to which he replied, "about three generations." We have been aware of this fact and in our interviewing of people we find that the candidate's family background often reflects the ability of the student in English Composition and effective presentation. One area in which we feel college training could assist is by allowing the engineering student to make original write-ups of his experiments and not the sterotype form which has been quite prevalent. In this way he will be given the opportunity to express himself. Here, as in many other fields, practice is a great help.

Changes in Pre-College Training

Many of our people felt that some changes were in order so that colleges would be provided with more qualified high-school graduates to insure that an increasing number of capable people entered the engineering profession. Many of our people have the same impression as expressed in the report and we recognize the difficult position of the college to affect changes in the secondary school. It is always possible to get more engineers by lowering our academic standards, but we have always felt that this should not be done and that our standards should be raised continually at all levels in our educational system.

In addition, we believe that more emphasis should be placed on counselling and guidance in the high-schools. Aptitude and interest tests should be taken by all students and they should receive vocational guidance from qualified individuals. Even more important than this, I believe, there is a matter of inspiration from the individual teachers. In science we know this is an important factor. Many people will enter the profession because an individual high-school teacher has inspired the person to go ahead with the study. I am sure the same thing is true in engineering. But it may well be that it is in the first years of college where the inspiration and encouragement of the engineering professor is most effective.

Early attention should be paid to studying and reading habits, since these make such a profound impression upon the whole study course of the individual. A course in comprehensive reading might be made available to high-school students as an elective subject. But here again the student must realize the importance of taking these courses and their value to him throughout the rest of his life.

College Educational Methods

Many of our people pointed out that the similarity and the knowledge of the concepts of the basic engineering fields should be emphasized. Much of the tendency in recent years has been to emphasize differences in engineering education and how many different fields can be made of engineering, when in reality many of these refer back to the same principles and we lose more by this extreme diversity than we gain.

Some college men have told us that it is necessary for them to develop many intriguing fields which appeal to entering

students. Using a specific example, many schools are considering, and may be giving, a degree in nuclear engineering. We feel that the college can hardly give a man in four years enough basic training in both science and engineering to make him a good nuclear engineer. It is therefore better to give the basic training in physics and one of the engineering fields and then provide him with the means of learning the necessary nuclear engineering practice after he comes to work for the company. At the same time, we realize there is a recruiting problem for the colleges, because many of these engineering areas, particularly the new ones, have an appeal for the student and more people will go into this area if there is a particular fascination for them. We object to the large number of engineering fields, and we do feel that the emphasis should be on the same basic principles with a real minimum of variation of the basic course.

New Technology

I would like to talk for a few moments on the role of engineering and applied science for the future. In doing so, I should first like to review some of the broad trends in engineering. There have been a great many changes in engineering and in education in the past 30 years, and I can assure you that in engineering there will be a great many more in the next decade. Many doors in the long corridors of scientific progress, that once seemed so impregnably closed, now stand ajar. Some have been forced by wartime "crash" programs, and we in education and in industry are forging the keys to others in our laboratories. New technology is becoming available at a continually accelerated rate. Its effective application for the benefit of mankind is both an opportunity and a challenge. Extensive and adequate plans and preparations that will lead to and insure good management of our technological effort and resources are of utmost importance to all of us.

As one of the characteristics of our technological progress, Dr. James B. Conant has spoken of the "lowering of the degree of empiricism." The old-time inventor, often a brilliant example of the individual empiricist, has been largely replaced by teams of scientists and engineers. You might say that we attempt to synthesize a composite genius out of many specialists. The complexity of our problems and systems requires such joint efforts. Today, it is very infrequent that one engineer can know enough about all pertinent technology to fully exploit it in conceiving and creating new devices and new forms of devices. As the degree of empiricism in our science and engineering is lowered, the level of engineering competency must simultaneously be raised, through education, and in other ways.

The broad advances in technology still leave many unsolved problems in their wake requiring extraordinary effort and expenditure to overcome. For example, there is the barrier to substantial improvement in the machines used for the conversion of the energy of natural fuels to useful form because of the lack of adequate high-temperature, high-strength materials. In fact, the lack of adequate materials is more and more becoming the prime factor in the limitations to design improvement in much of our machinery. Hence, great effort and large sums of money are being expended by industry in an effort to push back this barrier.

It is very important to note at this point that the most significant contributions in new technology are those that touch off a chain reaction in product concept and design.

If I am to discuss the future role of engineering in industry, I should first say something about the economic background against which we must plot its ever-increasing stature. I shall not include in my comments any extensive references to the needs for defense. I believe that this has been sufficiently emphasized and this problem for our times was wonderfully summed up by Alfred North Whitehead as long ago as 1917 when he wrote: "In the conditions of modern life the role is

absolute, 'the race which does not value trained intelligence is doomed.' Not all your heroism, not all your social charm, not all your wit, not all your victories on land or sea, can move back the finger of fate. Today we maintain ourselves. Tomorrow science will have moved forward yet one more step, and there will be no appeal from the judgment which will then be pronounced on the uneducated."

Graduate Study

It was gratifying to learn of interest being developed toward graduate study in engineering since we feel this area is of increasing importance to our Company. As I have already mentioned in my discussion of new technology, areas of interest to us are requiring men trained in depth in science and engineering. We must not expect to find the men trained in depth coming out of school with a Bachelor's degree. In specific terms, the complex technology involved in much of the work being done in companies like General Electric actually calls for the greater experience and the training in depth possessed by men who hold a PhD or equivalent degree in mathematics or the basic sciences. Too often, however, we are still assigning this work to people whose qualifications are something less. This practice has produced some gallant struggles and —eventually—satisfactory results. But it has on occasion cost us dearly in time, lost motion, and quality of performance.

I believe that this same need exists, or soon will exist, throughout industry. The complexity and volume of the knowledge and understanding necessary to us dictate an urgent and continuing need for a relatively small number of people highly trained in very narrow disciplines.

Now, are these men good for anything else, and have we any channels for their development? It seems to me the answer to these questions is clear: They don't have to be anything else. It is true that this kind of gifted person will most often become dedicated to a narrow field of interest and his development will be in increasing depth. But this is exactly the man we need so badly at the frontiers of our complex and growing technologies. He is our main hope of assimilating technological change so it can be translated into useful forms. What we need to do is get him out there on the frontier, recognize his value, and keep him happy there, and pay careful attention to what he tells us. Also, from time to time we shall need to call him back to help us with peculiar phases of our current technological problems, and this two-way communication between him and us cannot but be helpful to both. In our actual experience these highly trained men develop in two directions. Some become more deeply engrossed in their own particular field and become outstanding specialists, while others broaden as they apply their knowledge to wide areas. The latter group can provide excellent management material since our operations are becoming more highly technical in nature and these men possess the training to make decisions.

What should we expect of young people coming to us with the Bachelor's degree? Remember they are the people who are going to work behind the frontier, translating technology into timely, useful goods and services. First and foremost, we should not expect them to be great experts in current practice and applications. The reasons why are clear: the volume and complexity of technology are much too great to be adequately presented in an undergraduate course, and the rate of change is too high. Overnight, today's detailed practice can be made obsolete by a single technological advance. What we must look for—what we must have for this job of utilizing technology—is young people who are versatile, and it would seem that there is only one sure way of getting them. They should be trained in breadth.

Off-Campus Research

Although it is recognized there are distinct advantages in requiring residence

for all graduate study, we must realize that there is going to be increasing pressure on universities to allow off-campus residence for graduate students. For example, there is little need for such a provision on the Penn State Campus since few research institutions or government laboratories are located in the vicinity. With other universities, however, there is increasing pressure to allow this type of graduate work. At one of the universities, for example, just outside of Washington, D. C., an extensive graduate and undergraduate program has been set up with the Armed Forces and government laboratories in the area. This type of study satisfies a real need. Educators will be required to make a decision on how to cope with this problem and since it is one that is likely to be with us for some time, it may be better to set the boundary conditions under which this graduate study may be allowed than outlaw it completely.

Academic Standards

There has been some industrial discussion, and I am sure university discussion, on the possibility of accrediting graduate schools in the same manner that under-graduate schools are accredited. I am not posing any solution to this problem at the present time, but pointing out, as I am sure you are already aware, that such accrediting would help many of us in evaluating graduate study at many of our universities.

As part of this problem, I would like to point out one aspect which has caused us some concern. This matter pertains to the change in status of the Master's degree. In many schools giving a Doctor's degree, the awarding of a Master's degree indicates that a candidate has been unsuccessful in his pursuit of doctoral study. He may, or may not, be a better student than an average Bachelor man, although he should have been to get accepted into graduate school. We feel that it is important that the universities maintain their standards just as high for Master's candidates as for any other degree so that the degree means the same thing at all universities. It is true that there is pressure on all graduate schools to accept more candidates to fill laboratory and teaching requirements. These efforts for college instructors should not be allowed to effect major changes in our academic standards.

College Notes

Lee L. Amidon, the head of the Mechanical Engineering Department at **South Dakota State College**, has been cited by the American Society of Mechanical Engineers for his service on the student branch of the Society. Amidon was a member of the student branch committee from 1950 to 1954, serving as chairman for two years. He was instrumental in starting several improvements in the work of student branches in the Midwest which are being considered for adoption by other regions.

Princeton University has announced graduate fellowships in an engineering curriculum of fundamental research in plastics which will lead to the degree of Master of Science in Engineering. The fellowships are particularly suited to chemical, electrical, and mechanical engineers and to chemists and physicists. Applicants must hold a Bachelor's degree in engineering or physical science from a recognized institution, and they must meet general admission requirements of the Princeton Graduate School.

Physics for Engineers*

By JOHN A. SAUER and DONALD E. HARDENBERGH †

There has been of late a great deal of discussion concerning the teaching of physics to engineering students. Under the auspices of the National Science Foundation, special conferences have been held in which both engineers and physicists have been assembled to consider calmly and collectively the general topic. Committees of various national societies such as the ASEE and the AAPT have also been investigating the problem for some time, as have also many local committees in individual colleges and universities.

Interest in this field together with the concomitant reexamination of the value of the general physics courses to the engineer has arisen largely because of the following situation.

In recent years numerous new developments have taken place in science and technology. To mention but a few, there are

1) The development of the whole field of nuclear energy with its manifest applications to both war and peace-time uses.

2) The development of aircraft and missiles with propulsion units and shapes that permit them to fly at many times the speed of sound.

3) The advent of the semi-conductor and transistor with their many uses in the fields of communications and computation.

These developments and others have led many engineering educators to feel that in their college and university training, future engineers should be given some training in the basic principles of atomic and modern physics. With this point of view there is very little dispute between physicists on the one hand and engineers on the other. In fact, in a steadily increasing number of institutions the general physics course, which has formerly dealt only with classical physics, has been expanded to include fundamental concepts of atomic and modern physics. For example, at the Pennsylvania State University all engineering students now take 12 credits of General Physics of which the last 3 credits are devoted to principles of atomic and nuclear physics. As another example, at a recent conference [1] where 18 different academic institutions were present, 7 reported that their engineering students received a course in atomic and modern physics of from 35 to 55 hours duration, and only 1 institution stated that no work at all in this field was given.

Where a dispute does appear to arise between most physicists and some engineers is in the time to be devoted to the so called classical physics. A few engineers feel that classical physics per se should be taken away from the physics department and some of the component parts of the subject be covered by the individual engineering departments which are most closely associated with that field. This is by no means a majority opinion among engineering educators but it is one that has been publicly expressed.[2]

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[1] Conference on Mechanics in Engineering Education—Gould House, N.Y.U., January 1955, sponsored by National Science Foundation.

[2] J. D. Ryder—AIEE Winter Meeting, New York, 1955.

According to this plan the physics department would be alloted approximately one-half of its present number of credit hours and asked to use this time for a coverage of atomic and nuclear physics. This plan has two serious disadvantages.

1) It destroys the unity of scientific subject matter that exists in physics and will make it materially more difficult for the student to recognize that the principles developed in one branch of science are in many cases applicable to the problems of another.

A study of recent progress in applied science and technology indicates that the problems encountered frequently cross over many fields and that the engineer who is asked to solve such problems must have a deep, integrated and thorough knowledge of the basic principles of the various branches of physics. This point is well brought out in a report of the Grinter Committee [3] of the ASEE which states:

"... translation of new scientific developments into engineering practice will be facilitated by emphasizing unity in scientific subject matter. For example, there is a great deal of similarity both in conceptual understanding and in analytical methods among the generalizations of heat flow, mechanics of fluids, electromagnetic fields, and vibration theory. When a student understands these generalizations, he has gained a concept of systematic orderliness of many fields of science and engineering which enables him to approach the solution of problems in widely diverse fields, using the same analytical methods."

Thus any proposal to separately break up the component parts of physics and teach these component parts in separate courses in different departments would only cause a loss of integration and unity and thereby would less adequately prepare the students for meeting and solving new problems and new situations.

2) The second disadvantage of the Ryder proposal is that it fails to appreciate that developments in modern and solid state physics as well as developments in engineering science and technology depend to a great extent on a background and understanding of the principles and methods of classical mechanics and heat and of classical electricity and magnetism.

[3] Interim Report of the Committee on Evaluation of Engineering Education, A.S.E.E., June 15, 1954.

More "Classical" Physics

Both for follow-up courses in more advanced phases of physics or for preparation for solution of engineering problems, the student should have more, rather than less, of so-called "classical" physics. This does not mean more in the sense of additional topics—in fact the present number is already too great and should be reduced—but more in the sense of greater emphasis and time on the fundamental aspects of the subject. This is not only our opinion but is one of the expressed conclusions of one of the joint conferences of engineers and physicists sponsored by the National Science Foundation. We quote from their report [1]:

... the conference recommends that the basic physics course be strengthened by greater emphasis on fundamental classical principles and conservation laws, and by an introduction to wave and quantum concepts. Inclusion of these topics is an essential introduction to the later study of solid state or nuclear physics."

Setting aside the Ryder proposal, the question then remains: Can we strengthen and improve the training of undergraduate engineers so as to better fit them for the complex and difficult engineering problems that they are likely to encounter after graduation? All people concerned with this question seem more or less agreed that such problems require a solid basic training and that a strong, basic foundation is more important than subsequent proficiency in standardized techniques or computations of a specialized field. The Grinter report [3] already referred to, in speaking of the type of engineering problem likely to be encountered by the engineering graduate, states:

"Their solution, in turn, requires the

application of thoroughly understood fundamental principles and well ordered analytical thinking. . . ." Hence this report goes on to say that one of the instructional goals of engineering education should be to help the student "to learn to deal with new situations in terms of fundamental principles, on his own initiative, and with confidence and sound judgment."

It seems to us that there are a number of ways of improving the education of future engineering students so as to develop these traits. We propose the following steps, some of which have already been carried out by some individual colleges and universities, but many of which have not:

In the area of General Physics

a) Emphasize the fundamental principles of classical mechanics, thermodynamics, electricity and magnetism, and whenever and wherever possible show how the methods and techniques of one branch carry over into the others.

b) Illustrate the principles by use of examples, not taken by and large from the domain of engineering science, but wherever possible from the domain of physics. This is in accord with a stated conclusion of the joint conference [1] of physicists and engineers already referred to, viz.,

"It is also recommended that as far as possible, such particles as electrons, protons, and neutrons be used in the elementary physics course to illustrate general dynamical principles."

c) Omit extraneous material which does not have any direct bearing on the objective of developing an understanding of fundamental principles and conservation laws and above all else avoid racing through a large series of topics in survey-course fashion.

d) Use concepts of calculus wherever applicable not only as a means of time saving but also to foster facility in analytical computation so useful and necessary in most subsequent work.

e) Avoid giving laboratory instruction in the form of precise and definite orders and plan laboratory instruction so as to develop thought and inquiry.

f) Introduce basic concepts and principles of atomic and nuclear physics so as to provide the engineer with recently acquired scientific knowledge that he may well be called upon in the future to "translate into engineering practice".[3] This will also provide the student with an excellent opportunity to use and integrate the knowledge of methods and principles of the various branches of classical physics which he has just studied. It was concluded by the Conference on Mechanics[1] that in those institutions where 2 years are already devoted to general physics the additional material on modern physics could be included without requiring additional time. On the other hand, in those colleges and universities where only 1 year is now devoted to general physics, it was recommended that at least one additional semester be added to the general physics course.

In the area of subsequent engineering courses

a) For those engineering courses conventionally following the general physics course such as the first specific courses in mechanics, electricity, and thermodynamics, it should be kept in mind that understanding of the basic principles of the field is still a major goal of instruction. It should not be expected that sufficient mastery of these principles has already been attained in the preceding physics courses. Such mastery only comes after continued study. In this connection, it should be noted that even those students who major in physics rather than engineering are all required to take so-called "intermediate" courses in mechanics, electricity and magnetism, and thermodynamics. These courses still stress fundamental classical ideas and their applications to physics problems, and it is only after such courses have been mastered that the students are introduced to modern physics and quantum mechanics.

b) Engineering instructors should be aware of what has been covered in the general physics course and should re-emphasize the same fundamental laws and principles, but with emphasis on examples chosen largely from the engineering fields. In this connection, it would be an excellent idea for the individual engineering departments and the physics department to exchange instructors. In this way, subsequent correlation with a minimum of unnecessary repetition is assured. This system has recently been tried at Penn State with excellent results.

c) Just as for the general physics courses, the concepts of calculus should be used wherever practicable. It is the feeling of the writers that even in some institutions where the calculus course precedes the courses in statics, dynamics, electricity, and thermodynamics, full advantage of this fact is not taken and an opportunity to integrate the students' educational achievements is lost.

Conclusion

To summarize briefly, it is our opinion that the Physics course for engineers should be at least a 3 semester course and should place greatest emphasis on the development of the fundamental principles and conservation laws of classical physics. At the same time, an introductory treatment of the concepts and principles of atomic and modern physics should be included. Concepts of calculus should be used throughout the general physics course and all subsequent engineering courses. These subsequent engineering courses should also be taught not only as a first course in a more specialized branch of engineering science, but also as an added opportunity to provide the students with a greater degree of understanding of the fundamental principles of their field of study. Interchange of staff members between engineering department and physics department is advocated.

College Notes

The **New York University** College of Engineering Graduate Division will offer next spring the first university course on the use of scintillation counters as research tools. The course is intended principally for medical research staffs using radioactive tracers. Dr. Richard Stephenson, an Associate Professor at N.Y.U., will conduct the new course.

Dr. Paul P. Ewald, Thomas Potts Professor of Physics and head of the Physics Department at the **Polytechnic Institute of Brooklyn**, was recently elected an honorary member of the Societe Française de Mineralogie et de Cristallographie. Only eight men in the world today have been elected honorary members of this leading French mineralogical and crystallographical society.

The Institute of Statistics at **North Carolina State College** is sponsoring a seven day short course in statistical methods for research workers in industry and physical sciences starting February 12, 1956. This program is designed to acquaint research workers in industry and physical sciences with modern techniques of statistical analysis and experimental design. Guest lecturers will include W. G. Cochran, Johns Hopkins University, S. L. Crump, University of Rochester, and J. S. Hunter, American Cyanamid Co.

Engineering Education in Brazil

By EDWARD W. KIMBARK

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Brazil is the largest country of Latin America; it has about the same area as the United States but only about one-third the population. It is richly endowed with natural resources but is much less industrialized than the United States. The Brazilians want their industry to expand and it is, in fact, now expanding rapidly, thus requiring an increasing number of engineers. Brazilians admire the technical achievements of the United States; they buy many American automobiles and much American machinery, are entertained by American movies, and read American technical literature. Many American manufacturers have sales offices, assembly plants, and even some factories in Brazil. Americans, for their part, drink an enormous quantity of Brazilian coffee, thus completing the circuit of commercial interchange.

There has been also a considerable amount of "cultural interchange" between Brazil and the United States, one phase of which is that American professors have lectured and taught in Brazil; another, that Brazilian students and professors have studied in the United States. The writer recently returned to the United States from a stay of more than four years in Brazil, where he taught at a Brazilian engineering school (the I.T.A.), and thinks that his observations on engineering education in Brazil may interest members of the A.S.E.E.

There are (by November, 1954, data) 19 engineering schools functioning in Brazil. Of these, 5 are in the State of São Paulo, 4 in the State of Minas Gerias, 2 in the Federal District, 2 in the State of Pernambuco, and one in each of 6 other states. This distribution by states follows roughly the relative order of industrialization. Most of these schools are run by the states; a few are federal schools; a few are Catholic; and a few are private. All of them, however, receive federal subsidies and are controlled by federal legislation—a subject about which more will be said later. Two of the three branches of the Armed Forces (the Army and the Air Force) have their own technical schools of college level. The Navy, not having such a school of its own, sends some of its officers abroad for technical study.

A quantitative comparison of the extent of engineering education in Brazil and in the United States can be made in several ways, as tabulated below:

	Brazil	United States	Ratio
Population (millions) (1950)	52.6	150.7	0.35
Area (millions of sq. mi.)	3.29	3.02	1.09
Number of engineering schools (1954)	19	218	0.09
Number of engineering graduates (1952)	1,063	27,155	0.04
Number of engineers	16,000	400,000	0.04

These figures show that both the number of engineers and the rate of production of additional engineers are much smaller, in relation to the population, in Brazil than in the United States. This is natural in a country but little industrialized. However, the number of engineers in Brazil is only 40% of the number which would be required if Brazil should be content with a situation corresponding to that of the United States in 1890—a situation with which she does not wish to be content.

Civil Engineering Predominates

It is interesting to note the branches of engineering studied in Brazil. Of the 1063 graduates of 16 Brazilian engineering schools in 1952, 733 received diplomas in *civil engineering,* 89 in electrical engineering, 64 in civil and electrical engineering, 57 in electrical and mechanical engineering, 42 in industrial and mechanical engineering, 25 in industrial and chemical engineering, 19 in civil and mining engineering, 13 in industrial engineering, 9 in architectural engineering, 8 in mining engineering, and 4 in civil and industrial engineering. There were also a few graduates in aeronautical engineering, which were not included in the statistics quoted. The overwhelming predominance of civil engineering diplomas (82%, counting combination diplomas) is natural in a country having relatively little industry. Machinery can be imported, but buildings, roads, and dams must be built on the spot. Even the curricula other than civil include many more C.E. subjects than do the corresponding curricula in the U. S.

Engineering courses in Brazil are of five years' duration. The first two years are basic and more or less common to all curricula, the last three years being more specialized. There is almost no graduate study in engineering in Brazil. There are no evening courses and no cooperative courses, as we understand them, although a few engineering schools have summer surveying camps or require summer industrial work.

The biggest engineering schools are the National School of Engineering of the University of Brazil in Rio de Janeiro, the School of Engineering of Mackenzie University in São Paulo, and the Polytechnic School of the University of São Paulo. Each of these three schools has three or more different engineering curricula, and between them they furnish about half the number of engineers graduating each year. Many of the other engineering schools have only one curriculum apiece.

The National School of Engineering, owned by the federal government, appears to set the pattern for most of the other engineering schools.

The Polytechnic School of the University of São Paulo is generally considered to be the best Brazilian engineering school as well as one of the largest. One of its good features is that associated with it are two institutes to do testing, development, and research for industry and for the state of São Paulo and its municipalities, to maintain standards of measurement and to perform calibrations, to provide laboratory facilities and instruction for the School, and to conduct extension courses. One, the Electrotechnical Institute, performs these services in the electrical field; the other, the Institute of Technical Researches (I.P.T.), operates in several other fields, such as strength of materials, wood preservation, soil mechanics, and metallurgy. The University of Brazil also has an Electrotechnical Institute.

Mackenzie University is a part of Mackenzie Institute, which is unusual in that it combines on one campus in the city of São Paulo instruction from kindergarten through college. It is of especial interest to Americans because it was founded by Americans and has an American president and treasurer, who are Presbyterian missionaries, and an American board of trustees. There seems, however, not to be much American influence left in its engineering school, which has been obliged to conform to the pattern set by federal government regulations.

American influence on Brazilian engineering education in recent years has appeared mainly in the Technological Institute of Aeronautics (I.T.A.), run by the Ministry of Aeronautics of the Brazilian federal government and located in São José dos Campos, 60 miles from the city of São Paulo. This school is the first unit of the Technical Center of Aeronautics (C.T.A.), the second and much newer unit of which is a Research Institute of Aeronautics. The basic plan for the Center was formulated by an American professor, Richard H. Smith, about

ten years ago at the request of the Brazilian government. Professor Smith was later named as the first Reitor (academic head) of the I.T.A. The two subsequent Reitors have also been Americans, as have been several dozen of the professors. The I.T.A. has three curricula: aircraft, airways, and electronics. Most of the students are civilians.

Brazilian engineering schools, besides having the quantitative deficiencies already mentioned, generally suffer from the following defects: lack of autonomy, rigidity of curricula, high number of hours of class, poor attendance, too much emphasis on examinations, too little use of textbooks, inadequate laboratory apparatus, and too little contact between professors and students outside of class.

Lack of Autonomy is Basic Defect

The really basic defect, from which most of the others spring, is *lack of autonomy*. The curricula and the regulations on admissions, examinations, graduations, etc., are laid down by the Ministry of Education in Rio de Janeiro. Federal inspectors are located at each school to see that the regulations are followed. If a school should choose not to follow the regulations, it would not only lose its financial subsidy from the government but would soon lose its students, too. For the graduates of engineering schools cannot legally practice engineering until after their diplomas have been registered by the Ministry of Education, which registers only the diplomas of the schools which it has approved. Although, undoubtedly, the regulations were adopted for the purpose of maintaining standards of excellence, they have had the unfortunate effect of stifling improvement also, since the schools are not free to experiment with curricula and with educational methods. Professor Anísio Teixeira expressed the situation as follows: "Our activities are tied up in red tape, and we are all powerless to settle the questions which should be settled by our professional conscience because nowadays all of us, deans and professors alike, are merely appliers of laws and regulations." And, on the other hand, Dr. Maffei, Director of the I.P.T., gave as reason for the success of that Institute, "We have no regulations."

As a result of the regulations, *the curricula are too rigid*. All students in a given curriculum take the same subjects, in the same order. There are no elective subjects and no options to suit individual interests. There is no provision for some students to take a lighter program than others.

The number of contact hours are high (40 per week, it is said, at the Polytechnic School in São Paulo), thus leaving little time to study.

The *attendance* at lectures is voluntary and, probably as a result of the high number of scheduled contact hours and the fact that many students are working to earn part of their expenses, it is poor—perhaps 30% on the average. The attendance at practical classes (laboratories, inspection trips, etc.) is obligatory and is much better—perhaps 80%. Many Brazilian professors feel that obligatory attendance at all classes would be preferable to the present situation.

Because of the shortage of time for study while classes are in session and because of the great weight given to final examinations, the students tend to do most of their studying just before final examinations. And as a consequence of this habit, at many schools the methods of cheating during examinations have been highly developed.

There is little use of *textbooks* such as we are accustomed to. Some professors issue mimeographed notes. At many schools, notes made by students, after being submitted to the professor for correction, are mimeographed and distributed to the class. Sometimes these notes are sold by the student union. One professor expressed the conviction that if he should publish what he knew his services would no longer be needed. This feeling is undoubtedly shared by others, for rarely

does one find a textbook written by a Brazilian professor. In the bookstores, both American and European technical books are available, but the volume of sales is small, not being boosted by "adoptions." A very few of the most popular texts (such as Sears' *Physics* and Dawes' *Electrical Engineering*) are available in Portuguese translations, and many others, in Spanish editions, which are easily read by the Brazilians. However, nearly all Brazilian engineers read technical English.

Laboratory equipment, even in the best Brazilian schools, is generally inadequate. Much of it is antiquated. This situation is, undoubtedly, the result of insufficient financial resources.

The usual relationship between a Brazilian professor and his students is very formal. The students seldom, if ever, see the professor outside the classroom, and thus have no opportunity to obtain clarification of points they do not understand. Many of the professors discourage the students from asking questions during the class. In justice to the professors, it must be stated that most of them have only a part-time appointment and must supplement their low salaries by doing other work, often much more lucrative than their teaching. It should be said also that the official outlines of the courses contain so much material that the professor must hurry to cover even a reasonable part of it in class.

One often hears the graduates of Brazilian engineering schools criticized as being "asphalt engineers" who want to stay in the big cities and who do not like to get their hands dirty. This condition may be partly a result of inadequate laboratory work in school and partly a result of old Brazilian traditions. I do not believe that this criticism applies to all the schools. At least I know that, at the Electrical Engineering School of Itajubá, the students themselves have built and installed much of the laboratory equipment.

In addition to having the defects discussed above, the Brazilian engineering schools are said to be handicapped by the poor preparation given by the high schools. This has a familiar ring. However, the charge is probably true.

I hope that the Brazilians will not take offense at me for having listed these defects, of which Brazilian engineering professors are already well aware. Indeed, they have pointed out these faults in much stronger language than I, in statements quoted by Dr. Paulo Sá in his report on "The Teaching of Engineering in Brazil," published in 1954 by the Brazilian Standards Association (A.B.N.T.).

What To Do About It?

If the Brazilian professors are so keenly aware of these conditions, why don't they do something about it? Well, sweeping changes are not easily made, especially when laws have to be changed first. I believe, however, that the time is drawing near when reforms will be accomplished. The report just referred to is one sign of the increasing discontent of Brazilian engineering educators with the status quo.

A very potent factor in the reform which I believe is impending is the existence of the I.T.A., which has shown that engineering *can* be taught in Brazil in a way different from what it has been.

The I.T.A., being under the jurisdiction of the Ministry of Aeronautics and not the Ministry of Education, has, fortunately, avoided most of the defects which are apparent in the engineering schools controlled by the latter. The faculty of the I.T.A. has almost complete control over curricula and course content and is continually making changes as experience points to their advisability. Nearly all the professors are on full time, and both students and professors live on the campus; thus the students can become personally acquainted with their professors and are free to consult them in their offices at any time. There is a highly developed system of counseling to help the students with both academic and personal difficulties. Much emphasis is placed on current classes (problems,

laboratories, and quizzes) with consequent de-emphasis of final examinations. Cheating is practically non-existent. Attendance at all classes is required. Textbooks are widely used, and the laboratory equipment is adequate in most subjects. Thus the I.T.A., though not particularly impressive in comparison with many good engineering schools in the U. S., is outstanding among Brazilian schools. It has been warmly applauded in many newspapers and magazine articles, as well as in the report by Dr. Paulo Sá, already mentioned.

The primary reason for the character of the I.T.A. is not that it has had many American professors but rather that the group of Brazilians who founded it believed that it should be patterned after American engineering schools. And, after its founding, it attracted some Brazilian professors, such as Paulus Aulus Pompeia and Luiz Valente Boffi, who were dissatisfied with Brazilian engineering education and saw in the I.T.A. an opportunity for improving it. The influence of such professors on Brazilian engineering education will continue long after all the American professors have left the I.T.A.

Another factor which I believe will play an important part in improving engineering education in Brazil is that a good many young Brazilian teachers are studying for advanced degrees at American engineering schools. While I am writing, three Brazilians from the Electronics Division of the I.T.A. are on leave to study in the U. S., one at Cal Tech, one at Stanford, and one at M.I.T. I am confident that these men will learn much more than the subject matter of the specialties which they came to study: they will see how some of the best American engineering schools are organized and run. They will, I feel sure, put such information to good use after they return to their own country, helping to bring about the reforms which seem imminent.

College Notes

Illinois Institute of Technology has named Dr. Joseph C. Boyce, associate director of the Argonne National laboratory, as its new vice president of academic affairs and dean of its graduate school.

Alfred University, Alfred, New York, has established a graduate program leading to a doctor's degree of philosophy in ceramics at the State University of New York College of Ceramics at Alfred University.

A gift of $15,000 to the **Illinois Institute of Technology** for the development of its industrial design department was made recently by the Sears-Roebuck Foundation. The funds will be used to finance extensive re-equipping of some laboratories and workshops of the design school.

This fall, three engineering educators are beginning a period of studying industry, it operations and its needs, under DuPont's "Year-In-Industry" program. Participants this year are W. J. Richardson, Associate Professor, Industrial Engineering, Lehigh University; R. S. Rowe, Associate Professor of Civil Engineering, Princeton University; and J. K. Walkup, Professor and Head of the General Engineering Department, Iowa State College. The "Year-In-Industry" program is designed to bridge the gap between the college campus industry.

Birth of a Research Project*

By H. A. MIKE FLANAKIN

Highway Engineer, American Trucking Associations, Inc.

Last fall, Dean Sams said administrators had often wondered how research projects came into existence. He began baiting White Conner, Merle Baker, and me and we spoke back. Naturally, the fish with the biggest mouth got the bait and the hook along with it. Anyhow, he said, "You, Mike, are it."

Later I began to wonder just what I had undertaken. After all I'm not even a doctor of philosophy let alone an obstetrician. So what do I know of giving birth to anything. It occurred to me it might be profitable to give you a day from the life of a director of an engineering experiment station. You can see by the program that I am on leave from Louisiana State University where I served as acting director of the station there. But for the program one might think I were employed by the American Trucking Associations, Inc. I don't know just what the truckers will be asked to pay for that plug.

Let's suppose you are newly appointed director of the engineering experiment station at your university. You know what your personal salary is. The Dean has told you that. He has told you that you have a budget. He was about to go into detail when a call came from the President's office so he will explain it to you later. It is still later.

You are now on your own. You have met your secretary. You then sit down to look over your budget.

Funds have been budgeted for several research projects. You are listed as the director of each project. One is in chemical engineering. Two are in mechanical engineering. Another is in electronics. Finally, there is one problem in nuclear energy. You have some $3500 for each. This is to cover supplies, equipment and graduate assistants. Your own training has been in any field except chemical, electrical, mechanical or nuclear engineering. But that dosen't matter too much since you haven't any laboratories anyhow.

By now you decide you should find out how the university administration feels toward research. A study of the auditor's report discloses that 20 per cent of the university's budget is spent on research. That looks good indeed. A closer study shows that 18 per cent is spent for research in agriculture. The remaining 2 per cent is divided among medicine, chemistry, physics, speech, psychology, sociology, engineering, etc. Well you just don't fight with farmers do you? Congressman Morrill started the A and M colleges but somewhere along the line the M seems to have gotten lost.

Maybe you should talk with the President himself. You find him most receptive. He has never refused a budget request for engineering research when properly justified. He does need to be convinced that the engineering faculty is interested in research. This strikes you as odd. Then he explains. Most of the requests have been short, terse, and little more than a row of figures. When he asked for an interpretation the impatient engineer said: "Oh, skip the whole thing."

The President is amenable to permit reduction of teaching load as an inducement for research. He does want a bona

* Presented at the Annual Meeting of the Southeastern Section, American Society for Engineering Education at Knoxville, Tennessee on 15 April, 1955.

fide project to be established. He also wants the man's research time to be accounted for. It seems his neighbor (not an engineer nor an ag teacher) was listed on the payroll as half time teaching and half time research. The professor taught two 3-hour sections of the same subject. He spent 4 afternoons a week in his garden and sat with the children on Wednesdays so his wife could attend her bridge club. So the President looks with a jaundiced eye on "payroll" research men.

The President is not too happy over the sponsored research program but he will permit it. He will allow a faculty member to direct a sponsored project to the extent of 20 per cent overtime. The faculty member may be paid whatever the sponsor allows for the director. What about reducing the teaching load of some of the research minded faculty so that they may have time to bring in sponsored research projects? How about expanding research laboratories and equipment as an inducement for outside funds? Maybe you had best go get the project first and then he will talk to you about these things.

Now, you have just returned from a meeting of research directors of industry, government and universities. You learned how basic research ideas formerly came from scientists in central Europe. This fountain head was cut off by World War II and the Iron Curtain. Scientists everywhere are looking to American Universities to develop the basic research. Have they risen to the occasion?

You learned of the "Billion Dollar Package." You asked for a pocket full of money and were told it isn't quite that simple. You must bid for the money. The medium of exchange is qualified research men and laboratory equipment. The bill of sale is a proposal showing the sponsor what he will get for his money.

Perhaps you should call on the department heads in the college of engineering. What is the answer? How many of you have heard this:

"Get some money and suggest what I should do and I will consider it."

"Why don't the sponsors tell us what they want us to do and then give us the money?"

"Get the teaching load reduced first."

"Lab work! We can't even get a machinist."

"How can I do anything unless I have some equipment and staff?"

"We don't need research for our courses, just pay my instructors more."

"Why should I and my department do a lot of research just so you can publish a report!"

Key to the Problem

Maybe that last statement is the key to the problem. Surely engineering scientists are not indifferent to the value of research. So you ask for permission to talk to the individual faculty members. Sure enough, even though they have heavy teaching loads they are digging around and trying to find out why things happen.

One man had found out that the first movement in a steel eye beam loaded at the middle occurs in the unstiffened top flange over the support instead of the bottom flange directly below the load.

Another had found that a supersonic sound wave directed toward a moving object could be made to indicate the speed and direction of the object. And there were many others.

You asked why weren't these written up as research papers. Why! they weren't big enough to be called research projects. There was nothing *spectacular* about things of that nature. So what is spectacular about an apple falling out of a tree!

Now you know what your job as director of the engineering experiment station is. There are faculty members who want to do research. There are sponsors (industry, government and your own board of regents) willing and anxious to put money into research. Your job is to bring the two together. You just remember that birth comes about when the bashful boy is brought to the willing girl.

Now that you know what your job is, how do you do it? It isn't easy. The

first thing is to give up your own ideas of doing any research yourself. You want to make the faculty member and the sponsor attractive to each other. You might start out by adding a bit of glamor to the poor guy doing the research. You remember the money in your budget for the projects you were to direct and couldn't. Why not take that money and publish results of some of the research these men have done?

You decide to have no names on the report except the author's and of course the university. You soon discover that there is truly nothing more beautiful than a man's own name in print. Soon you have convinced the faculty member that you are not seeking to glorify yourself and you have won his confidence. You send copies of these papers to prospective sponsors—don't overlook your own university board and administrative staff. Of course, these sponsors may never read the papers. One day, however, a proposal will come through with the researcher as the project director. Then the sponsor will remember that he saw that name on a university bulletin sometime back so he must be a good man. He will be much more receptive to the proposal. You find that it doesn't stop here. While the sponsor and the faculty member—the boy and the girl—are important there is one other party who must be pleased. That is the university administration—the girl's papa and all of her brothers and sisters.

Let's take the case of Professor A. You knew he had been projecting around his laboratory for a long time. Maybe he had something he wanted to do. You called on him and asked—diplomatically, of course—why he hadn't published any papers. He was reticent to talk. You knew already that a former director of the station had placed his own name rather prominently on all experiment station bulletins. He also insisted on editing all papers. So you showed the professor the new format. As an example, you had placed his name in the author's spot. There were no other names on the format. You could see that he liked it. He said he'd think it over. A few days later he brought the complete manuscript for a good sized bulletin. Remember how pleased he was when you took the galley proof for him to proof-read. Then, of course, he received the first printed copy even before they had all been bound. The real pay off came when Professor A received a letter from an industry wanting 100 copies of his paper. From then on you were Professor A's favorite publisher and he brought material for many more bulletins.

Now that's not all. A publisher must be rather intimate with his authors. You learned that Professor A wanted to do some field investigations for material for revision of his text book. You knew he even planned to take sabbatical leave and finance the trip himself. You suggested that he make a research project out of it. Why it was unthinkable! The university would *never* consider such a thing! How did he know? Had the university ever been asked? Let's try it anyhow. Finally he agreed to write up a proposal. Maybe you did get a few rather flowery words into the professor's thoughts. In the meantime, you had discussed the proposal—informally, of course—with the Dean and your Engineering Research Committee. You had had coffee with the Vice-President and found out he rather liked the idea. One day you had business with the Dean of the Graduate School who was director ex-officio of all research. Quite by accident this matter came up and sounded good to him. Finally came the day when the proposal went to the Dean. He approved. Just to make sure there'd be no delays you *walked* the proposal through the chain of signatures needed and the project was set up. Even so Professor A was still skeptical. A week before he was to leave you handed him a voucher for his advance travel money. You also had him authorize the auditor to deposit his salary checks in his own bank while he was gone.

Professor A got his material for his revised book. You published four Engineering Experiment Station Bulletins. Your university got some good publicity. But most of all the engineering profession was enriched with some additional basic information.

Let's see how Professor B broke into the treasure chest of the National Science Foundation. Your congressman announced, in the press, that an appropriation would soon be forthcoming. It would be good for your university to be among the first grantees. Professor B had a full schedule but you had already learned that busy professors were more apt to tackle additional work than those with light schedules. Professor B was supervising a brilliant young graduate fellow who was on your payroll. You knew he had a basic problem in mind for a thesis and later a dissertation. So the three of you sat down and read the NSF rules and regulations carefully. You three then got busy. Preparation of the proposal turned out to be a major research project but you were determined it would be good. You checked with the head of Chemical Engineering to see that the apparatus would work. You asked for review by the head of Mechanical Engineering to see that the mechanical equipment was properly designed. You brought in the Electronics man to consider instrumentation. Finally, the three of you were satisfied you had a good proposal.

Then came the chain of signatures to the President's office. He was out of town so you left it with his administrative assistant. And you waited. You knew the President came back but still no word. Now you had already talked to Dr. Waterman and Dr. Klopsteg. You knew they liked the project because it would (1) add to the store of basic scientific knowledge, (2) assist a deserving young scientist to further his education, and (3) there was a shortage of applications from your area and they wanted to spread the money around.

Finally, after a month, you called the President's office. No the proposal had not been sent to the President for signature because the assistant just hadn't had time to review the proposal to see that it fulfilled all of the university and NSF mutual requirements. You blew your top but the proposal got approved and the project got under way.

Just one more example. One day the director of research for an industry called on you. He wanted to know what would happen to one of their new products when subjected to natural elements in your State. This was a rough one. You knew the young professor who should do the work. Trouble was it involved two departments. By devious ways including a cocktail party and dinner—paid for by industry, of course—you got the girl and all of her brothers and sisters to sit down with the boy and talk things over. Industry was reticent about publishing reports. This was overcome. The President's assistant wanted a patent protective clause. No patents were involved but he'd just read about the money Wisconsin makes from patents. Finally with a little greasing here, a little giving there, a contract was signed. Industry got its information; the young professor got a nice bonus; the university got an adequate amount for indirect costs; the experiment station got an additional 10 per cent for basic research and everyone prospered.

Review in Retrospect

Now you sit down and review in retrospect. It doesn't look as if you, the director of the engineering experiment station, have done anything. There is not a single report with your name on it. You have made no personal contribution to the fund of scientific knowledge. You have received no pay other than your regular salary. Yet and still you have perhaps the most gratified feeling of anyone. To you it is like the story the Bishop told about marriage. Here is a man (refer to Figure 1) and here is a

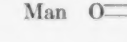

FIG. 1

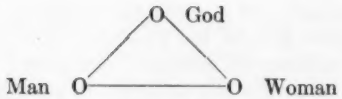

FIG. 2

woman. They love each other and get married. The bonds flow in two directions and the structure is not too stable.

Now here (refer to Figure 2) is a man who loves God. And here is a woman who loves God. The man and the woman love each other and form a union. This results in a triangular truss, which is the strongest structural shape there is.

You have been a party to such an arrangement. You have brought a faculty member and an interested sponsor together. They have a common interest in the university.

Additions have been made to the fund of scientific knowledge.

Your own life has been enriched as a byproduct. Your reward is good.

Program for Mid-Winter Drawing Division Meeting

January 26–27–28 Chicago, Illinois

Illinois Institute of Technology

Thursday, January 26. Executive Committee Dinner—6:30 p.m.

Friday, January 27. General Session—10–12 noon.

Papers by: E. G. Pare, "Technical Drawing for Science Majors." (IIT)

H. C. Messinides, "Design Consideration in Engineering Drawing." (Wilson Junior College)

L. M. Sahag, "The Relation Between Engineering Drawing and Machine Design." (Alabama Polytechnic Institute)

Luncheon and Business Meeting—12:15 p.m.

Inspection trip, *Chicago Tribune* plant—2 p.m.

Banquet and Address, Kungsholm—5:30–8:00 p.m.

Saturday, January 28. Open House, IIT Technical Drawing Department.
General Session—10 a.m.

Papers by: J. Gerardi, "Should Colleges Teach Drafting Techniques?" (University of Detroit)

J. H. Bergen, "Simplified Drafting." (American Machine and Foundry Corp.)

A. S. Levens, "Introductory Nomography." (University of California)

Luncheon and optional field trip—12 noon.

The Young Engineering Teacher*

By PHILIP WEINBERG

Purdue University; Chairman, Comittee for Young Engineering Teachers

When I received an invitation to report to this eminent body about the activities of one of its newer committees, I could not help but recall my own initial experience with the Committee for Young Engineering Teachers. I had the pleasure of attending my first national A.S.E.E. meeting at Dartmouth in 1952. There I attended a YET session where there were but a dozen people present. This was not a very large group, considering that half of the gentlemen were on the program. I was amazed at the enthusiasm and perseverance that these young people possessed, for here were a few hardy souls imbued with an idea that one did not have to be within ten years of retirement before he was active in his professional society. During the five years in which the CYET, The Committee for Young Engineering Teachers, has been officially organized, it has been gratifying to see how this committee has grown steadily in activity and acceptance by the senior membership.

The Committee's origin stems back to 1949. The farsighted Society leadership, having sensed the lack of participation in Society affairs by its younger members, empowered an interim committee headed by Professor F. L. Schwartz to study the problem. The committee was requested to explore areas of interest and organize sessions, conferences, and other activities specifically for younger members of A.S.E.E. This group prepared a report which was published in the JOURNAL in 1950, and on its recommendations, the Committee for Young Engineering Teachers was established.

Broadly the aims of the Committee are:

(1) To help the young engineering teacher orient himself into his dual profession, that of engineering and education; and

(2) To provide a mechanism by which YETs might be recognized and utilized so that they might be of service to engineering education.

The Committee encourages its sectional representatives to stimulate activities among younger people by such devices as institutional seminars, luncheon meetings, sessions at sectional and national meetings, and the paper contest. In this manner, attention is focused on the problems of the younger teacher, and this in turn assists the YET in visualizing his own problems.

Problems of Importance

When the CYET was organized, some thoughts were expressed that such a committee would have little value because the young engineering teacher did not have problems sufficiently unique to warrant special attention. A moment of reflection would show that there are a number of specific problems which should be of considerable importance to the YET. One purpose of this Committee has been to focus attention on these problems.

The Young Engineering Teacher should be concerned with

1. His professional education as a teacher

The new teacher has to solve such problems as development of effective teaching

* Presented at the General Session, Annual Meeting of ASEE, Penn State University, June 20, 1955.

style, fresh methods, means of evaluating the student, and counseling techniques.

2. Obtaining industrial experience

The YET needs to develop insight in the subject matter he is teaching.

3. Pursuing formal education and higher academic degrees

Every young man who wishes to grow in his profession must seek new knowledge. Pressure by administrations compels him to pursue advanced degrees.

4. Institutional policies and procedures

He has an interest in opportunities for advancement, financial remuneration, security, and problems of this type.

5. His professional development

In addition to the other facets of his development, he might be concerned with the publication of articles and textbooks and the methods of obtaining research contracts.

6. Social development

The YET has probably been up to his ears in intense specialization prior to his entry into teaching. He is usually just beginning to develop his personal and community relationships.

All of these factors present significant problems to the Young Engineering Teacher. By pointing to these situations, the CYET has attempted to satisfy one of its broad objectives, the orientation of the YET into his profession.

A second major aim of the Committee is that of providing service to engineering education. The CYET has assisted the Society in its Membership Campaigns during the past two years. It has established local contacts at most engineering schools through its sectional sub-chairmen. Most important, it has provided a mechanism through which younger members have had an opportunity to participate in Society affairs. In this way, young engineering teachers displaying promise have been recognized and tapped for service in many of the Society's functions. Many young men who have cut their teeth in serving the CYET have since diffused into other committees of the Society. Prior to the establishment of the CYET, it was difficult for younger men to be spotted for service early in their careers. As a further attempt to provide a means of expression, it is hoped that the recent appearance of *YET-itudes* in the JOURNAL will provide an open forum for the enthusiastic and uninhibited ideas of younger people.

I have attempted with these few remarks to give you a general picture of this Committee and its scope. Detailed information about the YETs appears in a very interesting article written by Professor Robert Howe which appeared in the JOURNAL in November 1954. The title of this article is "YET's? What's That?"

Education As a Teacher

I have previously mentioned six areas of development that should be of interest to the Young Engineering Teacher. The first point mentioned was the YET's concern for his professional education as a teacher. I would like to discuss this point further. We in engineering education have made little attempt to develop teachers of engineering. It has been tacitly assumed that all that is necessary for a man to become a teacher is to acquire the necessary academic preparation and then to put the man into a classroom. When the young man selects college teaching as a profession today, he finds practically nothing in the form of organized planning to help prepare him for this work. Engineering educators should consider some type of organized program designed exclusively for the development of the engineering teacher.

I suggest that the ECAC, Relations with Industry, and Young Engineering Teachers Committees study the feasibility of organizing an annual summer workshop in which a young teacher who has been teaching a short while, say less than five years, will have an opportunity to prepare for his profession. Perhaps one summer period on the subject of educational theory and subsequent summers in specific industrial assignments would help broaden his own perspective and deepen

his appreciation for the engineer he is nurturing. It would be conceivable that an inducement to attend the workshop might be a quarter's credit toward the Ph.D., if he doesn't already possess it, and a fellowship with some nominal remuneration to compensate for lost income. In normal times, perhaps such inducements would not be necessary, but at present, it is almost a prerequisite.

Would such a program be of value? There are indications that the number of available teachers with experience, advanced academic training, and a desire for teaching are not keeping up with growing enrollments. Some signs of a growing shortage are:

1. That the number of Ph.D.'s in engineering granted annually have not increased in the last four years, as may be noted in the *Journal Yearbook* for 1955. There is little likelihood that increases in the future will keep up with the demands for these people by industry and education. The educational institutions are running well behind industry in attracting these men.

2. It seems reasonable to assume that fewer people are selecting teaching as a permanent profession because of attractive opportunities elsewhere. This statement would be verified by most department heads. Consequently many institutions will have to rely on secondary personnel such as graduate students and part-time people.

A trained cadre of young teachers, perhaps obligated to conduct institutional seminars, can cause a diffusion of ideas and techniques which will help bolster educational qualities, this at a time when opposite forces are tending to lower these same standards.

Such a program would most certainly appeal to the young teacher. It would be highly beneficial to the engineering schools since it would place emphasis on an area that in the past has been sorely neglected, that of developing college teachers.

In summary, let us note that the sound development of engineering education for the future depends on the younger men of today. Their sound development will reflect itself into our colleges for many years to come. It is this major consideration to which the Committee for Young Engineering Teachers is devoted.

In the News

W. W. Gridorieff, chairman of the University Relations Division of the Oak Ridge Institute of Nuclear Studies, was recently elected as the first permanent executive secretary of the **American Nuclear Society.** Mr. Gridorieff succeeds Professor William M. Breazeale of Pennsylvania State University, who had acted as interim executive secretary since the Society's founding in January, 1955.

Dean R. C. Ernst of the University of Louisville recently announced a gift from Mr. and Mrs. William S. Speed of $450,000 to the **Speed Scientific School** towards the construction of a Civil and Electrical Engineering building. The growth of the Speed Scientific School since its establishment in 1925 has been closely related to the generosity of the Speed family.

Blurred Borders of Physics and Engineering*

By J. H. VAN VLECK

Dean of Engineering and Applied Physics, Harvard University

The only instruction received concerning the subject matter of this paper was that it should have at least some relation to the Conference on Electricity and Magnetism in Engineering Education which was held at Lehigh in February, 1955. Instead of emphasizing what was said or done, I am going rather to focus my attention on what was not said or not done, and stress that there was a salutary freedom from excessive dogmatism in the conclusions. I must confess that I approached the conference with some trepidation, as with a carefully arranged equal representation of engineers and physicists I was afraid that the meeting might savor of a knock-down and drag-out battle between two factions, reminiscent of a jurisdictional dispute between two labor unions, and equally pointless. Actually I was happy to discover that on the whole the union-card aspects were singularly absent.

The final paragraph of the report of the conference which carries the heading "cooperation to meet local situations" appeals to me as particularly significant. I reproduce it here in full, as it leads to the main thesis of the present paper.

"The conference recognizes that the jurisdictions for the various functions implied in its recommendations must vary from one institution to another as indicated by local conditions. It strongly urges sustained contacts between the departments of physics and electrical engineering in each institution by such means as frequent conferences and exchanges of teachers and personnel on research projects. The understanding gained by such contacts should make it possible for faculties to develop optimum engineering programs with their local facilities."

Cooperation in Wartime

This proposition that the physicist and electrical engineer can benefit greatly by frequent contacts and close cooperation strikes a most responsive note in me in view of my experience at the Radio Research Laboratory of Harvard during the war. Here electrical engineers and physicists were gathered together to work on a practical engineering problem, the jamming of the enemy radar. It was clearly demonstrated that physicists and engineers each have something to learn from the other, and that it is futile to talk of one discipline as being the superior of the two. It is today a cardinal fact and the substance of many reports on engineering education, that science is involved in far more complicated ways in modern engineering devices than in times past. In this connection I cannot do better than quote from the report of a panel headed by Vannevar Bush which was concerned specifically with engineering problems at Harvard but nevertheless contains much sagacious general philosophy on the interplay of science and engineering.

"The borderline between the engineer and the applied scientist is becoming dimmed. It has never been clear cut. . . . Engineers, those who are in the forefront of advance, are becoming more entitled to be recognized as scientists in their own right. Applied scientists, under the pressure of war and its aftermath, have often become accomplished engineers as well."

* Presented at the Annual Meeting of ASEE, Penn State University, before a joint meeting of the Electrical and Physics Sections with the American Association of Physics Teachers, June 21, 1955.

At the Radio Research Laboratory, and at the closely allied Radiation Laboratory of Massachusetts Institute of Technology, which was concerned with radar itself rather than its counter-measures, I learned that the leaders in the research and development program immediately at hand could be men who had achieved distinction either as engineers or physicists. The Harvard laboratory, incidentally, was staffed dominantly by engineers, and that at Massachusetts Institute of Technology by physicists, but in either institution there was close integration of the two disciplines. I learned that what one might call good physical intuition and real engineering know-how were, to be sure, to a certain extent complementary, but nevertheless were usually merely semantically different definitions or specifications of the same attribute; a man who had one quality generally had the other.

Cooperation in Peacetime

These remarks which I have made concerning the benefits of liaison between physics and engineering have so far been centered around the war effort, but in my opinion they apply equally well to educational efforts in peacetime. It is sad but true that in many colleges and universities there is not today the same infiltration of physicists and engineers in a common effort that prevailed in the war laboratories. The fact that they are usually located in different buildings and often in different schools, and belong to different faculties accentuates the difficulties of liaison, but nevertheless it remains that close cooperation and mutual understanding is a highly desirable goal. If a physics department or engineering division feels that it has nothing to learn from the other, the chances are that something is the matter with at least one of the two—most likely the one that thinks it has nothing to learn.

It perhaps will seem rather shocking to suggest that sometimes an engineer might try giving a course in physics, or vice-versa. Whether this is practicable depends on local conditions, the breadth of a man's interest, and especially his ability as a teacher. I was gratified to see that one of the headings of the report is labeled "Need for Experimentation in Curricula" and makes explicit the wish that "no action taken by it (the Lehigh conference) be interpreted as discouraging experimentation by the universities in altering the content of its courses, or in changing the location of courses within departments."

Electricity is probably the branch of physics and engineering where these two disciplines overlap and dovetail more intimately than in any of the other standard fields. My personal experience in teaching the junior or senior course in electricity is confined to the war years when the regular staff was on other assignments, but my observations there convinced me that the basic course in circuit analysis, i.e., the one beyond the usual preview in an introductory physics course, is a sort of triple-point where mathematics, physics, and engineering meet. No one of the three disciplines is involved in very high echelons, but the union of the three presents a liaison which can well be baffling to the student who tends to compartmentalize his knowledge. In mathematics, nothing more recondite is involved than complex algebra and differential equations with constant coefficients. In physics the primary concepts are of inductance, resistance and capacity, along with impressed EMF. The engineering aspects involving resonance, transients, tunable circuits and the like are probably more intuitive to the present radio-minded American youth than they were thirty years ago. Nevertheless the fusion of the three disciplines, the transition from the complex plane of the mathematician to the tuned circuits of the real world appears as a very subtle *tour de force* to the beginning student, in which drill and guidance are necessary for the man of average ability, and the services of a good drill-master or expositor are invaluable. His quality as a

teacher is far more important than the department in which he is housed.

I may give two examples of men from my own institution particularly qualified to teach across the board. Our junior course in electromagnetic theory at Harvard is given by R. V. Pound, who is ostensibly a physicist, but who won the B. J. Thompson Memorial award prize of the I.R.E. in 1948 for his frequency stabilizer. For the other example I go back to the time when I was a graduate student in 1920 and took a course in thermodynamics with Harvey Davis, later to become president of Stevens Institute of Technology. This course, though it pointed towards engineering applications, brought out with remarkable clarity the physical meaning of such concepts as entropy, reversibility, and the like, and consequently furnished a remarkable educational opportunity for any physics student.

Albert Einstein

No one will deny that outstanding physicists differ widely in how much flair they have for the world of engineering and affairs. This fact is illustrated by two men whom America has lost in the last few months, and who rank with the greatest physicists of all time—Albert Einstein and Enrico Fermi. No one can mention their names this year without paying them tribute. I have had the good fortune to have known both of them, though my acquaintance with Einstein was mainly at the time of the Solvay Congress of 1930. Some of Einstein's discoveries, notably the relation $E = mc^2$ and the photoelectric equation, have had revolutionary repercussions on modern engineering science. As Dean Freund aptly said at the annual meeting of the Steel Founders' Society of America in Chicago, March 15 of this year, "$E = mc^2$ has importantly influenced each one of 2,500,000,000 people who live in the world, with the possible exception of 30,000 Eskimos and a scattering of bushmen in the interior of Australia." Still I do not think anyone would be tempted to classify Einstein as an engineer. In fact, research in the later period of his life was primarily mathematical and cosmological in character.

Enrico Fermi

The case of Fermi is different. It is true that most of his career was that of a physicist, but not to recognize his contributions to engineering in atomic power would be as unimaginative and unappreciative as not to accept him as a great American on the ground that he was born in Italy and spent roughly the first half of his years of scientific productivity there. To be sure, Fermi did not pretend to be a man of affairs, or pound the table, and there were some to whom his soft-spoken Italian manner did not carry conviction. However, there was one engineer, a leading figure in the Hanford project, who listened to Fermi with the greatest care and particularly valued his counsel. That man is now president of du Pont.

Anyone who heard the paper presented by Zinn (the present director of the Argonne Laboratory) at the special ceremonial session of the American Physical Society held in honor of Fermi last April was shown in no uncertain terms that his work in the design and construction of the first atomic pile under the west stands of Stagg Field was one of the great engineering achievements of all time. One can argue *ad infinitum* as to definitions of what constitutes engineering and what constitutes physics, but by any rational measure, this pile was a masterpiece of engineering. Earlier in this program, Dean Bewley mentioned that a physicist is a man who seeks to understand nature and an engineer is one who seeks to utilize it; an atomic pile is pretty clearly an instrument of the latter category. It is also said that a physicist analyzes, an engineer synthesizes; the careful addition of successive bits of uranium to (or rather subtraction of cadmium from) the pile until it became self-sustaining is an example *par excellence* of synthesis. Another criterion for

separating the engineer from the physicist is that the former is concerned with problems of design; and the first atomic pile is certainly an epochal example of pilot-plant design. The design problem was a particularly baffling one, not only because of the novelty and complexity of the project, but also because the constants involved were inadequately known, and because any error in design might have tragic consequences, both in terms of human life and the direction of the scientific war effort. For instance, it was not known how the various cross sections and other constants connected with neutron capture and diffusion varied with temperature, especially at the high temperatures which should be associated with a self-sustaining pile. Consequently, even the sign of the temperature coefficient of the reactivity of the pile was not known. This was most disconcerting, for if the temperature coefficient were positive, the heat developed by the onset of the chain process might make the reaction become more and more violent, not so much so that the pile would become a bomb, but enough for it to explode or disintegrate, and cease to be useful. This uncertainty Fermi circumvented by inserting electric heating coils in place of some of the uranium rods, and analyzing the effect on the neutron flux when these coils were heated. In this way it was found that the temperature coefficient of the reactivity was negative and the thermal changes would not lead to a catastrophe. In this, and in many other ways, Fermi's atomic pile was a monument of careful planning. His later contributions to the Los Alamos program and to the problems connected with the plutonium plant at Hanford were also notable.

It has been argued in certain quarters that because physicists are these days so much concerned with problems of nuclear physics, they have wandered too far afield from classical physics and from the design problems of the engineer and that consequently the courses given by the physics department for the engineer should be confined to atomic structure and similar subjects. However, I think a very good case could be made to the contrary—that the large pieces of apparatus involved in nuclear physics have made the physicist design-conscious and made him more conversant with problems of mechanical and electrical engineering than in the past. The Chicago synchrocyclotron was Fermi's concern in the period following the war, when he could devote his attention to pure research. An example of one of the design problems involved in this huge machine was the moving from one place to another around the cyclotron track of the target to be irradiated by the beam coming out of the machine—a problem in some ways like rotating a telescope from one setting to another, but with the complication that the instrument was located in the radiation-danger zone, and so could not be touched during the moving processes. Fermi himself built the car or truck shown in Figure 1. It is a little hard to find a name for it. Among physicists it has come to be known as "Fermi's trolley," a rather inappropriate designation inasmuch as no power was applied to it through wires. Instead, for power, it used induction effects from the magnetic field of the cyclotron itself. In other words, the trolley carried only, so to speak, the armature of a motor. Also it needed no rails, because its wheels fitted the rim of the lower magnet pole. By remote control a safely located push-button experimenter could start or stop the car at will. Even the wheels were constructed of lucite, to avoid eddy currents. In her excellent book,* Mrs. Fermi in discussing her husband's work on the Chicago cyclotron says, "Enrico built a small gadget for the large gadget—'Fermi's trolley'—a platform of lucite mounted on four wheels, looking as if they came from an erector set. . . . It looks very neat except for a sloppy joint of wires, conspicuous in front of the platform.

* Laura Fermi, "Atoms in the Family," University of Chicago Press, 1954, pp. 262–263.

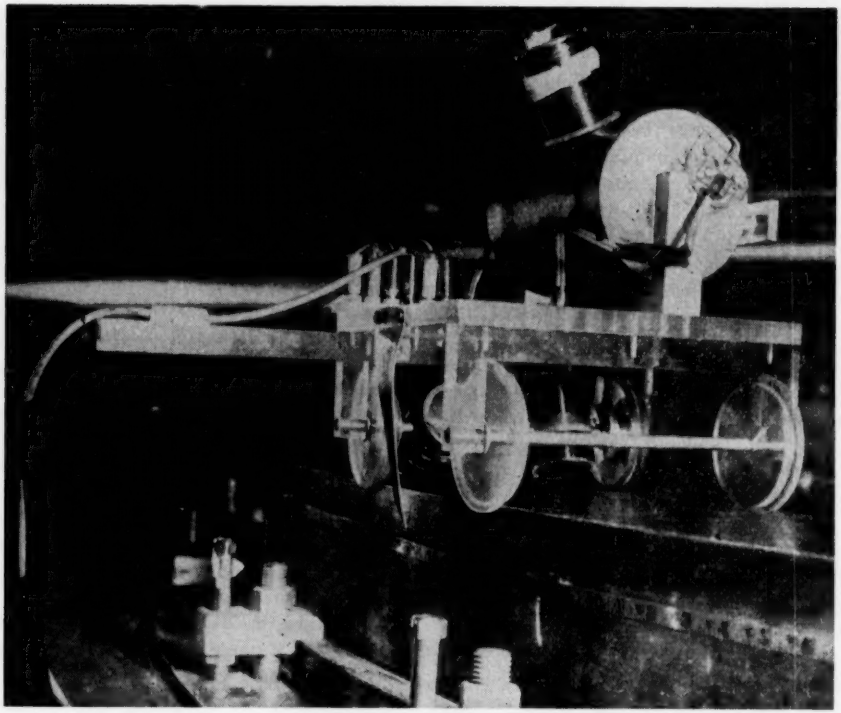

FIG. 1. "Fermi's Trolley."

A man's nature never changes. Enrico has always given attention to performance and disregarded appearance." That the problem in design was not an elementary one is shown by the fact that two other physicists tried to copy the idea without success—at least initially—for in one case the apparatus burned up from *rf* induction effects; a scientist of another cyclotron laboratory once ruefully remarked, "In my city we do not have Fermi's trolley, only 'A Streetcar Named Desire'" (then playing at one of the theaters).

Examples like this show, I think, pretty clearly that apparatus of nuclear research, because of its size, complexity, or high power, can involve real problems of design in electrical and mechanical engineering. Complicated drawings, specifications, etc., are found in physics laboratories today which are a far cry from the simpler pieces of apparatus of the turn of the century, which Goudsmit aptly characterizes as the old string and sealing-wax days. When Harvard awarded an honorary degree to Fermi, President Conant referred to him as the one man in America who was a whole physics department in himself, an allusion to the fact that he was both theoretical and experimental, and from time to time even gave the most elementary course in physics at the University of Chicago as well as advanced graduate lectures. The citation might well have said that Fermi covered many segments of an engineering school as well.

Thomas Alva Edison

So far I have discussed a man generally classed as a physicist, but who has made notable contributions as an engineer.

I shall devote the remainder of my time to the converse case, of a man who is generally considered to be an engineer or inventor, but who has made an outstanding contribution to physics. The example I take here is Thomas A. Edison.* Although one usually thinks of him in connection with the electric light, gramaphone, and other similar projects, his discovery of the Edison effect, which is essentially the phenomenon of thermionic emission, as early as 1883 was a cardinal advance in physics. The rectification properties associated with the negative charge of the electron were latently visible in his experiments. The significance of his observations was not properly appreciated until after the discovery of the electron by J. J. Thomson in 1896. Had the physicists of the 1880's followed up Edison's observations with the zeal that they merited, we might have had the thermionic valve, radio, and the like, a quarter of a century earlier.

It is interesting to compare some of the points of resemblance and diversity between our two great engineer-physicists and physicist-engineers, Fermi and Edison. Both men possessed a flair for the practical as well as a curiosity for how things work. Edison's practical talent, to be sure, was much more on the engineering than the economic side; as he was a poor businessman. With his 1093 patents, the largest number ever given to one man, one is apt to think of the Wizard of Menlo Park as interested only in problems of application. It is true that economic and other pressures kept him working dominantly on the applied side, but he had a real curiosity for understanding nature as well as utilizing it. Edison himself said, "I was a poor manufacturer. As soon as I have finished a machine I'm anxious to take it apart again in order to conduct an experiment. That's an expensive mania for a manufacturer. My ambition is to be able to work without regard to expense. What I mean is that if I want to give up a whole month of my time and that of my establishment to finding out *why* one form of a carbon filament is better than another, I want to do it without having to think of the cost. That galls me. I want none of the rich man's toys. I want no horses or yachts—I have no time for them. What I want is a perfect worshop." It seems sad indeed that Edison could not have had the independence of a modern research laboratory, be it industrial, governmental, or academic.

Another point of similarity of Fermi and Edison is that they pioneered in new fields, and did the unorthodox. When Edison termed his first firm one in electrical engineering it was regarded as almost heresy from the traditional standpoint. He said, "Everything is so new that each step is in the dark. I have to make the dynamos, the lamps, the conductors, and a thousand details the world never hears of." Fermi could have said the same thing in 1942 when he tried to chart the passage of neutrons through carbon and uranium.

There is one respect in which the chronicles of discoveries of Fermi and Edison are different from each other and from what one might at first thought expect. With the currently prevalent idea that interest in science and technology is a comparatively new development, one might conjecture that Edison's discoveries would have gone more or less unheralded, and had little immediate repercussion on the financial world, and that the reverse would be true of Fermi's findings. Actually, Edison's pioneer work attracted wide notoriety. Some three thousand people were transported in special trains to see early demonstrations of the electric light. Each improvement immediately depressed gas stocks, and on one occasion there was virtually a panic on the London stock exchange. On the other hand, the first chain reaction on

* The information on Edison's career in this paper is culled mainly from "American Science and Invention," by Mitchell Wilson; Simon and Schuster, New York, p. 286 ff.

December 2, 1942 went virtually unnoticed except in highly classified echelons. Not even Fermi's wife knew what was taking place. Of course, the initial secrecy of the advent of atomic power was connected with war time security, but in Edison's case there is, I believe, another angle that should be mentioned. He had to advertise to get money for research, and his only source of income was through technological successes. His early invention of an improved stock market ticker was, for example, probably more a matter of expediency than deliberate choice of a field of endeavor, for financial transactions were not Edison's first love. At any rate, even at the age of thirty he apparently did not realize that a lump-sum payment of a given amount of principal could be capitalized and so was preferable to the same total payment distributed over a period of years. One can amuse oneself conjecturing what would happen if some one appeared on the scientific horizon today who gave promise of discoveries of originality, novelty, and importance comparable with those of Edison. Think of the competition of large industries to bid for him on their research staffs, or of universities to get him to head a government-financed research contract. Instead, Edison had to do his research the hard way, as an individual entrepreneur.

Some Conclusions

Perhaps I appear to have digressed too far from the theme of educational curricula in discussing Fermi and Edison as two prime examples of the engineer-physicist and physicist-engineer. However, I believe that study of their biographies is not without relevance to our educational pattern. For one thing, comparison of their careers shows the importance of advanced training under modern conditions. Edison had practically no schooling, even of the elementary variety, whereas Fermi had a Ph.D. It is doubtful whether someone even of Edison's genius could make his mark in equal degree today without further training, but fortunately there are available today many financial aids which had no counterparts fifty years ago. Of course, there is always the worry, expressed in many quarters, whether even with the financial avenues open, science and engineering attracts all those with native ability in it. Conceivably Edison, had he lived today, might have passed up higher education and ended up a super-technician in some laboratory rather than exploiting his full genius, for the frontiers of discovery are certainly much less accessible to the unschooled than they were fifty years ago.

Perhaps the greatest moral to be gained from surveying the careers of these two men is how futile it is to try and delineate ironclad borders between physics and engineering. This is true in educational curricula as well as research, and the greater the cooperation between the two groups, the greater progress will be. Had the import of the Edison effect been realized in 1883 we might have had the era of the vacuum tube much earlier than we did. This is not an indictment of our research physicists of Edison's time, however, because there were practically none in America at that time. On the other hand, recently the transistor was born as the brain child of the theoretical physicist rather than as a sheer empiricism like Edison's early tube discoveries. The contrast again illustrates the difference between research conditions then and now.

In closing, I must caution that I do not want to give the impression that there is no difference between an engineering and a physics temperament. There certainly is. The fact that after the war Fermi went into cyclotron research dealing with mesons rather than becoming a big wheel in the atomic power industry, as he could undoubtedly have done, shows clearly that he was at heart a pure scientist. It is idle speculation whether, with a different background and training, Edison might have developed differently—it is fortunate that his career was as it was. One thing is clear—despite different nuances in temperament—engineers and

physicists of the first rank can traverse the frontiers between the two disciplines when occasion demands, with highly beneficial results.

Of course, the objection might be raised that the two figures whom I have discussed are not typical. The average faculty member is no Fermi or Edison, much less so the students. However, we must set our sights high, and look to our leaders for inspiration, guidance, and example—otherwise we may be mired in the morass of mediocrity and routine.

In preparing this manuscript the author has benefited from correspondence with Dr. Herbert Anderson, whom he wishes to thank. The photograph reproduced in Fig. 1, was taken by Mr. Stephen Lewellyn.

Mid-Winter Meeting of Cooperative Drawing Division

January 9 and 10, 1956 — The University of Akron

The two day session will include discussions of "Ford Method to Encourage Use of Co-ops," "Home Reading for the Co-op During His Work Period," "The Value of My Co-op Experience to My Present Employment," "Are Co-op Schools Selling the Co-op Plan Short?" and "Professional Attitude and the Engineer." A Workshop Session will center around pertinent problems in cooperative education. Arrangements are being made by Mr. Earle Hamlen, Vice Chairman of the Cooperative Education Division, and Associate Professor of Coordination, University of Akron.

Annual General Assembly Engineers Joint Council

January 26 and 27, 1956 — Hotel Statler, New York City

Major features of the program will be problems of utilizing engineering manpower, the growth pattern of the engineer, and the engineering aspects of the Hoover Commission reports.

Problems in Communication in the Engineering Science Curriculum*

By WARREN E. WILSON

George Westinghouse Professor of Engineering Education,
The Pennsylvania State University

Dean Christensen's request that an attempt be made to fit the subject of this paper into the general theme of the summer school, namely, "Communication: Experiment and Experience," seemed to present very great difficulty at the time. However, as the end of the academic year approached, it became more and more apparent that many of the problems associated with the Engineering Science curriculum were really basically problems in communication. It is necessary, however, to acquaint you with the objectives of this curriculum and describe it briefly before presenting for your attention some of the problems in communication which have confronted us and in several cases still lack a solution.

The Engineering Science curriculum was established a little over two years ago on our campus and during the current year, had enrolled in it fourteen Juniors and nineteen Sophomores. This curriculum was designed specifically to educate students who wish to enter the fields of research, development and other creative aspects of engineering. The curriculum is broader than that of the specified professional curricula and the student is given work in all major engineering sciences with special emphasis on fundamentals and the relationship between the various sciences. This curriculum is more demanding than the others and provides an excellent training for industry as well as preparation for graduate work. Students in this curriculum must maintain at least a 1.5 average during their college careers.

The curriculum is characterized by the following features:

(a) The freshman year is the same as that of all other engineering curricula. This permits students to transfer from any other engineering curriculum at the end of the freshman year without difficulty. Since, however, the curriculum is designed only for the better students, and especially for those who expect to do graduate work, transfers are only permitted provided that the student's grade point average is 2.0 or better.

(b) A course in mathematics is given each semester throughout the four years.

(c) An average of one non-technical course is provided each semester throughout the four years.

(d) One foreign language, German, is required for a two semester period and more languages may be taken among the twelve credits of non-technical electives during the last two years.

(e) In addition to a course in Modern Physics, this curriculum provides a laboratory course in Atomic Physics and a course in Optics. Other physics courses can be taken as technical electives during the last two years.

(f) Eighteen credits of technical electives are provided during the last two years. Of these eighteen credits, nine credits must be scheduled in an approved sequence in one of the well-defined engineering fields.

* Presented at the ASEE English Division Summer School, The Pennsylvania State University, June 24, 1955.

The curriculum was established under the auspices of a committee appointed by Dean Walker and is governed by a curriculum committee composed of several members of the original group and others in addition. The Engineering Science Committee formulates policies to be followed in the administration of this course of study. Administratively, there is no actual department of Engineering Science but the writer acts as department head at the present time. The teaching load is carried by members of the departments offering the various courses. The procedure for the selection of these teachers has been quite simple and direct. Each department is informed of the courses which must be taught and is requested to nominate the best teachers available. The teachers are not under any compulsion to teach these courses and may elect not to do so if they so desire. In addition to the acting department head's usual duties, he also has the obligation of carrying on studies in Engineering Education and finds it most convenient to use this curriculum as an experimental medium.

Four Lines of Communication

Within this curriculum, the lines of communication may be described quite simply and are four in number. The first of these is between the curriculum committee and the department head. The second is between the department head and the teachers. The third is between the department head and the students and the fourth is between the teachers and the students. The number and orientation of these lines differ in no essential way from those of the ordinary department if one notes that the committee on the curriculum simply represents the faculty of the college as a whole. However, there is a marked difference in several cases in so far as the ease and adequacy of communication is concerned.

As suggested above, there are significant differences associated with the four lines of communication compared with those of the ordinary curriculum. We shall first consider the mechanics of these lines and then investigate in detail problems that have been associated with each.

The first line of communication, that between the committee and the department head, is similar to that which ordinarily exists between the faculty as a whole and the department head and the dean and the department head. In actual practice, it differs slightly in that the department head is chairman of the committee and finds himself, therefore, in the position of taking the initiative and guiding the curriculum but feeling restrained to call upon the committee for advice and counsel when new situations requiring policy decisions are involved.

The second line of communication, that between the administration and the teachers, differs in two important respects from the usual. In the first place, the teachers are not members of the department of Engineering Science, hence the common relationship of department head and staff member does not exist. On the other hand, these teachers are all voluntary teachers and are enthusiastic about this experimental program and prone to communicate their ideas more readily and extensively than is commonly the case.

Communication between teachers and administration and among the teachers was fostered by three meetings during the year. All teachers concerned with the curriculum were in attendance and discussed at considerable length topics such as duplication of course material, better cooperation and coordination in the teaching of the courses, methods of grading this highly selected group of students and other most pertinent topics.

Communication between the administration and students differs from that of the other departments on this campus particularly due to the fact that the number of students concerned is very small whereas in the regular departments, the number is so large that no department head is able to communicate directly with his students.

Communication between teachers and students once again differs somewhat from

that in the conventional curricula. First, due to the fact that the group is small; secondly, due to the fact that some of the teachers meet with the students in more than one course and hence, get to know them very well and, thirdly, due to the fact that students and faculty both are extremely interested in this experimental program and tend to communicate much more readily than is ordinarily the case.

As has been indicated above, lines of communication are more open and accessible than is frequently true in standard curricula. However, we have been confronted with one extremely difficult problem of communication which pervades the situation at all levels. This problem is associated with the need to communicate the original concept of the founding committee to the department head, the staff and the students. The author feels that he, as the department head, has understood this concept which, incidentally, has been discussed in the literature of Engineering Education for many years. In fact, it can be traced back at least as far as the Wickenden Report in the late 20's. It will be assumed, therefore, that the communication from the original committee to the department head was successful. However, some of the present committee members were not members of the original committee and it was necessary to be certain that the original idea was conveyed to them. The next communication problem in this area was to make certain that the teachers understood thoroughly the features to be incorporated in the courses which would differentiate them from the conventional courses. A comparable problem exists in conveying basic concepts of the curriculum to the level of the students. This is particularly difficult since they had access to no such ideas in high school or in the freshman year.

Illustrative Situations

In order to illustrate the situations which have arisen, one problem will be discussed in connection with each line of communication. First of these is with reference to communication between the department head and the committee. An early problem of such a type is associated with the need for courses in design in the curriculum. Some members of the present committee felt that such a course is absolutely essential for any engineer. Others did not agree. It has been necessary, therefore, to refer to the members of the original committee in seeking a solution. To date, we have not really been successful in this quest. The major difficulty seems to lie in the fact that each member of the committee, who is himself a department head, visualizes clearly the needs of students in his own curriculum. It has proven impossible to project from the present undergraduate situation to that which will obtain fifteen years hence when these students have become active in their professions. Those who visualize their activities at that time attempt to imagine what they might need comparable to a present day design course. Those who feel that no conventional design course is needed find it very difficult to communicate to the other members of the committee their concept of an engineer who will design but has had no such course in design.

One of the most difficult problems is communication between administration and teachers. A fundamental concept associated with the curriculum is that the students must acquire knowledge of basic principles and that we must foster their ability to apply these basic principles to the solution of completely new, in fact we may say unique, problems. The conventional method of teaching in engineering colleges runs counter to this concept although many teachers will not admit it. Inspection of any standard text in engineering courses reveals that the practice is to present tools of analysis and to afford a great deal of practice in their use by working large numbers of quite similar problems. Quizzes and examinations regularly contain problems not very different from those in the textbook which were worked as homework. It has been difficult, therefore, to

convey the concept that the student should master the basic principles and develop facility in working problems which he has never seen before. Some progress was made in the direction of solving this problem by conducting a two-hour oral examination for each of the fourteen Juniors. Twenty-three faculty members conducted these examinations. Each student had at least four examiners in addition to the speaker. A number of the staff who thoroughly understand the objectives of the curriculum interrogated the students in such a manner that both staff members and students must necessarily have obtained a better appreciation of the objectives of the curriculum.

Communication with the students, particularly by the department head has been centered around an attempt to convey two basic ideas. First of these is the concept of Engineering Research which is of course almost unknown to students at the sophomore and junior level. The second idea is that of learning basic concepts and developing skill in applying them to new situations.

Progress was made in the communication of the idea of Engineering Research to the students through the medium of a weekly seminar. Research engineers and scientists talked to the students on such occasions and visits were made to several laboratories on the campus.

Equal success cannot be claimed in communicating the most important feature of the curriculum, a mastery of fundamentals. As stated previously, the oral examination for the Juniors undoubtedly helped those students. Nothing comparable was done for the Sophomores and attempts will be made next year, especially in the seminar, to assist the next year's Juniors in this manner. A new text and different staff for the courses in mechanics during the sophomore year are important factors in an attempt to assist in the orientation of next year's Sophomores to the desired viewpoint.

The students have raised several questions which it has been very difficult to answer and only partial solutions to the problem have been attained. For example, they are concerned with what future employers will think of this curriculum and what graduate schools may think of it. The most practical answer turned out to be the ease with which even sophomores in the curriculum obtained very good positions for the summer.

There is one area in which the open lines of communication have been most effective. This is associated with those difficulties which arise when students and teachers do not see eye-to-eye. On several occasions, students have complained either at the pace at which the course was progressing or duplication of subject matter. In each case, the simple procedure of making a telephone call and getting the interested instructors together has resulted in an effective solution to the problem. This happy situation is derived from the fact that the author can devote much of his time to the occupation of "watch dog of the curriculum." This might not be a practical solution in the case of a curriculum enrolling hundreds of students. However, it may point the way toward improvement in other curricula suggesting that open lines of communication between students, teachers and administrators are highly desirable.

An investigation which it is proposed to carry out next year is closely associated with problems in communication. It is prompted by a strong feeling that quizzes and examinations, which are obviously media of communication, function also as very powerful teaching tools. The experiment will be directed toward determining the effect of two different types of examinations on the students' progress in a course of study. One group of students, the control, will pursue a standard course with the usual quizzes and examinations of the routine problem type. The other group will study the same material but will be quizzed and examined on basic concepts and applications to new situations. The effect on the mastery of the material and development of skill in its use will be evaluated at the end of the semester by a comprehensive examination

given at the same time to both groups. The governing hypothesis in this study is that students will make a real effort to attain that which is expected of them as indicated in quiz and examination questions.

Summary

In summary and conclusion, one may truthfully say that problems of communication have played a major role in the organization and administration of the Engineering Science curriculum and give promise of continuing to be in the forefront for some time to come. Efforts will be made to solve the problems as they arise and it is hoped that solutions obtained may be helpful to others undertaking the establishment of similar curricula.

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Our Output Problem*

By EDWARD J. RISING

Assistant Professor in Mechanical Engineering, Kansas State College

Engineering education in the United States has a challenge to meet. Our output has fallen off nearly fifty per cent in the last four years.[1] Because of small entering classes in 1951–52 (ten per cent under the average since 1947 [1]), our production will stay low for the next two years. Industry clamors for more engineers; technical society publications view the present engineering personnel shortage with alarm. A recent article by M. H. Trytten appearing in *Mechanical Engineering* compared engineering education in the United States and in Russia.[2] This article presented data that indicates that Russia is graduating engineers approximately twice as fast as the United States. The purpose of this paper is to show some of the ways the output of engineering schools can be increased without sacrificing quality or lowering standards in any way.

Increasing the Output

Perhaps the biggest problem engineering education faces today is one of quantity rather than of quality. By and large, industry seems satisfied with the quality of our output. This is shown by the energy and money they spend each year trying to recruit engineering graduates. We of the engineering education profession can point with pride to our satisfied customers. Each year they come back in larger numbers, with more elaborate brochures pointing out the advantages of their companies. Our seniors get expense-paid trips to plants and home offices. The red carpet is rolled out for the engineering graduate of today, and it appears to be out to stay.

Often we read in our journals about the "shortage of engineers." Authors vie with one another in extrapolating figures to 1960 or 1975. But consider for a moment that the students we will graduate in 1960 are finishing their senior year in high school. What are we doing to make the needs of industry and society for engineers known to these people? What are we doing to publicize the advantages of an engineering career? For the most part, nothing!

Let us consider our output problem in a systematic manner. Our engineering background gives a logical approach through the functional relationship among output, input, and efficiency. We know that if we wish to increase the *output*, we must first increase the *input* and *efficiency*.

Increase the Input

In September, our graduating classes of 1961 are going to be starting their senior year in high school. For them, this next year is going to be the year of decision. If we are going to have more engineers in 1961 we must have more freshmen in 1957. There is, then, no alternative to going into our high schools and attracting these seniors.

If we could attract a large portion of this group of high school students, we would find that many would not meet the standards of any accredited engineering

* Awarded Honorable Mention in the ASEE Young Engineering Teachers Paper Contest of 1955.

1 ————————, JOURNAL OF ENGINEERING EDUCATION, Vol. 44, No. 6, Feb. 54, pp. 4.

2 Trytten, M. H., "Engineering Education in Russia," *Mechanical Engineering*, Vol. 76, No. 11, Nov. 54, pp. 882.

school. Of those who could meet the standards, some would not make good engineers for reasons of personality. There are, however, students who can meet the standards and would make good engineers; there must be reasons these students do not come to engineering schools. We must find these *reasons,* because in these reasons lie the answer to our input problem.

Could the reasons these students do not come be inertia, lack of funds, misinformation, poor publicity? To meet the financial difficulties that keep competent students from entering, more scholarships must be provided. Scholarships and funds now available should be used to their full extent. To overcome misapprehensions and lack of information, we must go to the high schools with our story. High school guidance people remember engineering employment as it was in 1950, and not as it is in 1955.

Generally each department or college of engineering has some ranking member assigned to placement of seniors. Would it be logical to assign some member to the procurement of freshmen? This may not be possible, but something should be done. Many private colleges have found that an active Director of Admissions who gets out and speaks in high schools, to various alumni groups, etc., can materially affect enrollment. Active alumni groups and interested individuals can all be effective boosters. Some means of copying these techniques should be instituted in schools that do not have them. Existing programs must be invigorated, and oriented to the need of society for engineers and to the opportunity engineers have in our society.

Increase the Efficiency

Perhaps one of the most effective means of bettering the ratio of the output of engineers to the input of freshmen would be to apply some quality control to the freshmen input. The purpose of such a program would be to exclude students who would not be likely to succeed at a college level, and to identify the weaknesses and deficiencies in preparation of students who have the ability to succeed. Such a system would be based on information secured on each entering student, such as high school record, data on the personality of the student, and the results of a series of tests given by the college.

If the goals of such a program could be met with precision, there would be many advantages. Much time, trouble, and money could be saved; advisers would be better prepared to counsel freshmen as to the fields for which they are best fitted. Such a procedure would also tend to forewarn the faculty and the student himself of any background weakness that might exist. Where weaknesses are known, creative measures can be taken. These efforts can be pinpointed to meet the specific needs of an individual *before* he fails a course.

When dealing with tests and measurements, we have the problem of the exception. The exception is a statistically insignificant fellow, but extremely important to himself. To compound this difficulty, some results of tests of this kind may not be clear-cut, since many persons have abilities that place them in a marginal group for our purposes. These difficulties are not beyond resolution since tests can be designed to meet carefully selected goals. We would not ask our tests to predict how well an individual would succeed in life (impossible), or how well he would succeed in college (difficult), or even whether an individual would succeed in college (reasonably easy). The test would be designed only to determine whether the individual had the equipment necessary to succeed in college (i.e., personality and mentality). If the student does not measure up to the standards of the college he should be rejected.

While the desirability of eliminating the poor material has been argued from the point of view of the college, an even better case can be made from the point

of view of the prospective student. It would be better to direct the energy of the student incapable of engineering toward a technical institute or trade school initially, rather than after he had failed in trying to master a higher education. For the individual, disappointment of relegation would be substituted for failure, obtainable goals substituted for goals unobtainable.

These carefully selected words are unnecessary when a private institution is concerned; colleges and universities supported by public funds are in a different category. Usually the prospective student entering a state institution needs only to earn a diploma from some high school in the state and it becomes practically impossible to refuse the student entrance on any grounds. Since the public colleges make up a large segment of our higher education system we must examine this admission policy that allows dissipation of resources and may tend to encourage situations that promote frustration. If the public institutions hold fast to an admission policy that allows the public to attend irrespective of ability, an economical classification system is obviated. The freshman year must be used as a classification test with the accompanying waste. This admission policy should be qualified, since no one should have the right to waste the substance of the state by working on a program for which he does not have the requisite ability. Such a policy then can become a means of saving resources by eliminating the obviously unfit, and a guide to the redistribution of these resources to those who need and can profit by the extra attention.

Every year prospective engineering students are dropped because they cannot seem to learn chemistry, physics, and mathematics. The bulk of these students have only casual contact with their chosen department. It is not argued that engineering students should take less or lighter work in these areas, nor is it argued that teachers in these areas are not doing their job. It is suggested, however, that students are getting more impersonal treatment in these departments, are getting herded into larger sections, and are getting less chance to work individually with their instructors than they receive in their degree departments. The difficulty has been approached with some success by sectioning courses on the basis of the ability and background of the students. The use of "honor sections" and "remedial sections" is a well known device that warrants wider usage.

Remedial sections, while helping to solve one problem, tend to create another, since they meet more often and receive the same credit as the other sections. This "stretching out" (extending the curriculum over longer periods than originally intended) can be dangerous unless it is accepted by the student. This problem is found often in another form: If a student fails a course, his first impulse is to take the course the next term. This is good, except that many students insist on keeping up with the class, which means they attempt to take all their regular work also. In this case the student has refused to recognize that he is being stretched out. It is particularly vicious since the students who are failing and taking the longer route through remedial sectioning are the marginal group. The overload caused by the extra work forced into the same period of time might well be fatal to them.

Systems for stretching out have been in operation for some time. One such system requires a student who has failed a course, depending on his cumulative average, to reduce progressively his course load including the repeated course. If the student's average indicates it is necessary, this system reduces his load to as little as three-quarters regular load and includes the repeated course and another course dealing with study habits, reading comprehension, etc. This system works two ways toward eliminating the student's problem. It stretches out the curriculum, and teaches the skills the student needs for academic success.

The Relation of Quality to Quantity

If we must have larger numbers of engineers and the needed students matriculate, does it necessarily mean that the quality of the graduate must deteriorate? Is there anything *a priori* in numbers that means reduced quality? A careful (although brief) analysis of the educational process will show that no deterioration need follow: in fact, some improvement of our graduates may occur because of an expansion, assuming adequate expansion takes place in our faculties and physical facilities. Three primary phases (as distinct from goals) of formal education will be examined—definition of content (curriculum), aiding the student to master the material (communication), and evaluation of his achievement.

The number of students matriculated should have no adverse effect on what may or may not be included in the curriculum. It might even be expected that some advantage might occur with greater numbers since larger selection of course offerings could justifiably be made with larger enrollments.

Another primary phase of the education process is communicating the ideas within the curriculum to the minds of the students. An individual having a thought he wishes to implant in the mind of another must deal with a complex system. The thought is communicated by being transformed into the written or spoken word; the word must be seen or heard, and arranged in the other person's mind in such a way that his behavior is changed. In the future, that person will react in a way that is conditioned by the thought transmitted to him; we have accomplished change in its most literal sense and every component of this change is liable to error. But is more error per student introduced because we have more sections of a given course? It would appear not, since the learning situation in one classroom is unaffected by what is happening in another room. Here again some advantage might be obtained, since larger enrollments can justify more equipment and teaching aids; more sections mean less difficulty in sectioning with better student schedules resulting. Student schedule improvement would not be a small gain, since we could not expect a student to learn much from eleven to twelve o'clock if he has been in class continuously since eight o'clock.

Objective evaluation techniques are necessary to judge accurately the accomplishments of the students. These techniques must also be developed so that quantitative experimental work can be done on our classroom communication problem. This lack of valid and reliable measuring instruments may limit some experimenting, but there are many fields in which much work can be done. Teaching aids, methods, reorganization of material can be tried in conventional or new forms. Every time a multiple-section course is taught, we have situations that lend themselves to controlled experimentation that should not remain unexploited. With larger enrollments we would have more multiple-section courses, and it seems clear that the additional sections would not increase the evaluation problem within the individual sections.

Summary

An engineering personnel shortage is a long-range problem that can not be solved immediately. However, we can start our solution immediately. These proposals offer steps that could be taken at once toward the solution of our output problem. The proposals deal primarily with the earlier portions of the college career where the mortality is highest; consequently they should represent a favorable beginning. The same type of organization should be extended through the entire curriculum and new techniques developed if we are to solve this problem. And solve it we must if the engineering education profession is to meet the needs of society and our national security.

Coordination of Architecture, Engineering, and Construction by the Project Method*

By JOHN F. POULTON
Virginia Polytechnic Institute

The answers as to how to coordinate—in what manner and where and when—are intimately bound up with the collective personality of the school. They are modified by the school's attitude toward each of the phases of building and they are limited by the solutions which can be found within a given faculty and within the confines of the four year program. Certainly the answers which we have achieved at VPI fall short of our ideals. They are answers which are not easily reached and which evolve slowly. At the end of this paper I shall try to indicate the nature of what we have attempted so far at my school but I believe that specific answers are not nearly so important as is a careful consideration of the questions.

The first question which occurs to me in this connection is concerned with the precise definition of the professional fields for which we are educating. For the purpose of our discussion it is probably enough to limit ourselves to the Architectural Engineer although I think precision of definition in the other two areas is also needed. It is quite apparent that we vary a good bit among ourselves in our concept of the profession. I should like to advance a particular definition here both because my school believes in it and because it is involved in the viewpoint from which this paper is written. It seems to me that the architectural engineer is an engineer who is thoroughly familiar with and in sympathy with the objectives of architecture. He must have as profound an understanding as possible of each of the many current structural forms and he must be as competent as possible in their analysis and design. To this extent his objectives coincide with those of the Civil Engineer and his standards of competence should be at least as high. But beyond this point the Architectural Engineer must extend his insight to include understanding of the impact of these forms on architecture in both the visual sense and the economic sense. He should have an open, imaginative mind able to produce a number of alternative solutions to a given problem. He should be able to assess and weigh the factors involved, both tangible and intangible, in order to make a discriminating choice among the solutions. He is an engineer *for* architecture. His education is successful to the extent that he is profoundly aware of his status as an engineer.

Probably the most important of the questions which arise is concerned with what we mean by coordination and why we desire it. In the years since the war we have been increasingly concerned with the concept, sometimes calling it coordination but more often integration. It has commonly been held to describe a broadening of education to the end of reducing the graduate's tendency to specialize and increasing his competence in the fields related to his own. Most of us pay a certain amount of lip service to this idea. But we are very much aware of the increasing complexity of each of the areas

* Presented at the Annual Meeting of ASEE, Arichitectural Engineering Division, Penn State University, June 23, 1955.

of activity within the building industry and we are very much concerned to produce graduates who will be able to meet the detailed demands made upon them. We know the direction in which we should go—toward a broader and better rounded professional man—but the actual conditions of practice inexorably push us in the other direction. It seems to me that, in reality, we have had no choice in the matter. The very great increase in the complexity of the several fields is unarguable and we are concerned with conducting an education for people whose abilities have a quite finite limit. I am convinced that these forces will continue to bear upon us and that we will have no choice to continue the process of fractionating the building industry. There is nothing in the history of architectural education in this country since the first successful school was begun at MIT in 1868 to suggest that the trend will be reversed.

It is frequently argued, notably by Felix Candela, that significant building can be accomplished only by a return to the idea of the Master Builder of the Middle Ages. This envisions a person who has encompassed all the knowledge we expect in each of the fields into which we have broken building. It is an exciting and stimulating thought but it seems to me that this kind of stature is possible only to the genius. If we are to take as our responsibility the education of *enough* people to fill the needs of our building industry then certainly the number of men of genius to be found among our students will be only a very small per cent of the whole. If Candela's thought is correct—and I think it is—we must seek a way to approximate the Master Builder. If we cannot achieve him in one person then we must try to approximate him in several.

Within this idea I believe we have the start to a better understanding of the notion of coordination or integration or whatever we wish to call it. Briefly, it seems to me the situation is this: building has become very complex—so complex that people of normal ability are unable to encompass all the necessary skills and knowledge involved in it. Indeed, they are hard put to attain real competence in even one of the fields into which we have divided it. Then, if these people are to contribute to significant building, ways must be found for them to bring their several abilities to bear on one project in the sense that a Master Builder would bring many abilities to bear on it. What is needed is a very considerable skill in collaboration and a recognition of that skill as an important element in the total competence of each of our people—the Architect, the Architectural Engineer, and the Contractor. The coordination required is not that which will give each individual some broadening of his technical competence into the fields adjacent to his own, but, rather, should increase his skill in the process of collaborating with those who are in the adjacent fields.

Of Primary Importance

In the past we have, to some extent, recognized the need for skill in the collaborative effort but I think we have not placed nearly enough emphasis upon it. We have acted as if it were a quality quite secondary to the student's technical competence and we have assumed that it could safely be left to be developed in the early years of his professional career. It seems to me that it is, in fact, of primary importance and that the schools must recognize education for the development of the skill as an added responsibility.

Moreover, this is one addition to our education which can be accomplished within the framework of a four year course for it involves no new subject matter. The ability to collaborate with others is made up principally of insight into the problems and objectives of the other fields and of a mature and healthy respect for the work of others. Education for the development of the skill can be accomplished through care in

establishing the sequence of work, through teaching which is consistently concerned with the relation of one field to the others, and, perhaps most important of all, through conducting education in an atmosphere of concern for the interests of all three fields.

The schools which offer curricula in Architecture, Architectural Engineering, and Building Construction are fortunate since the presence of all three curricula in a single department is helpful in establishing this atmosphere. When this is done much of the desirable effect comes about informally. The students observe each other's work and extend their awareness of problems beyond their own fields in casual conversations. Also, they are able to see a core of interests which is common to all three activities. The fact that such subjects as elementary design, elementary structures, and estimating are studied in joint classes tends to increase the students' understanding of the interrelationships which exist among their several interests.

It must not be inferred from what I am saying here that I believe it is proper or even possible to extract from each curriculum all of the technical material relating to either of the other two. On the contrary, I believe that an understanding of the basic concepts in all three fields is quite necessary to effective collaboration. The architect must be familiar with the fundamentals of mechanics before he can work cooperatively with the engineer. Moreover, there will continue to be circumstances in which it is desirable for the architect to be able to carry out simple structural design without resort to collaboration. There are also times when the engineer must undertake simpler architectural functions and he should be able to carry them out adequately. But it does not seem possible to extend the student's factual education in adjacent fields beyond the level of the fundamentals. It seems to me that education which attempts to do so is disregarding the nature of the present day practice for which the students are preparing, it is likely to give the student a poor understanding of the nature of his profession, and it is certain to leave too little time for the study of his own professional field.

The coordination we should seek is not that which invites the student's attention to every phase of building with each problem. Rather, it will consist in a more vigorous study of a single phase but with the relation of that phase to the remainder of building activity constantly borne in mind.

The final question which might occur to us is concerned with the meaning of the term The Project Method. In "Engineers and Ivory Towers," Hardy Cross says of engineering:

> "Engineering is essentially a craft. It is the glory of engineers that they are craftsmen, that they are artists, and while as good craftsmen they follow a systematic and orderly procedure, they are highly resistant and antagonistic toward overregimentation. They demand freedom for their art, freedom to recreate, to rearrange."

This is the concept of engineering which seems to me soundest and particularly so where Architectural Engineering is concerned. If we accept the concept and undertake to emphasize the idea of engineering as an art making use of science, then, in education, we must try to provide circumstances in which the student may explore the art and practice in it. It seems to me this is the idea we have in mind when we speak of the project method. We are concerned with the thought that the principal and most difficult phase of engineering is that of attaining insight into the problem presented by the whole building and that it is upon this problem that the student's attention must be focused. He must attack his problem in such a way as to achieve a unified and meaningful result. Only after he has determined the need of the whole building will he turn his attention to the individual structural elements which compose it. When he has done this he will

have his understanding of the unity of his work to bring intelligent discipline and order to his detailed computations.

The relative difficulty of the two phases of structural work has shifted. Not many years ago the problems involved in framing buildings lay largely in the field of mechanics. We were concerned with quality of materials, with analysis of linear frames in fairly simple senses, with means of jointing, and with foundation problems. We were able to feel that if we had become competent in these matters we had our subject fairly well in hand and that the application of our knowledge to an actual building was a simple matter. The means and patterns of framing available were few and stereotyped and were usually dictated by an architectural solution which had been reached with very little consideration of structure.

Multiplied Many Times

But recent years have seen multiplied many times the means of building available to us. The advent of such elements as structural glueing and welding, precasting and prestressing, folded planes and shells, diagrid framing and lamella forms—to name only a few—have made the matter of choosing structural materials and structural forms anything but simple. At the same time structural elements have become more and more important in the visual character of buildings. We are finding, especially in school buildings, the entire nature of buildings dictated by economic factors related to their framing. The choice of a structural solution has become a decision affected by many factors of which some are tangible and calculable but more are intangible and non-numerical.

As a consequence, then, the most difficult phase of the work of the Architectural Engineer lies in the selection of materials, forms, and arrangements appropriate to a given architectural circumstance and in the organization of his work to take the many factors into account.

Structural analysis and the design of individual structural elements are subjects as difficult for students as they have always been but they have become only tools in the solution of larger problems.

Under these circumstances, it seems to me that the most effective engineering education will be that which makes maximum use of the project method and minimizes lecture courses. The ASEE Committee on Evaluation of Engineering Education seems to have indicated the same sort of thinking in its recommendation of augmented courses in design.

The idea of minimizing lecture courses does not, of course, carry with it any thought of minimizing the attention given to theory of structures. The change is from a situation in which the theory is taught as an end in itself to one in which it is presented as an integral part of a given problem. The amount of teaching done is unchanged, it has simply been transferred to and made part of the courses in structural design. The work is given piecemeal as needed in successive problems. There are dangers in this method, of course. The student is likely to miss the generality of application of a given point. But this has always been true of structural theory under either method and the teacher has always had to be careful to make clear the extent of the area over which a given element of theory is applicable.

The chart which follows shows the way in which the Architectural Engineering curriculum at VPI is organized at present and the degree to which we have been able to put these ideas into effect.

Supporting Subjects		Courses in Design
		All Curricula
Fall 1st Yr. Fnd. Dwg. Intro. to Arch. Algebra	1	Elements of drafting
	2	Orthographic projection
	3	
	4	
	5	Isometric drawings
	6	Elements of descriptive geometry
	7	
	8	Shades and shadows
	9	
	10	
Wint. 1st Yr. Fnd. Dwg. Intro. to Arch. Trig.	1	Construction of perspective
	2	Perspective drawing
	3	Perspective drawing
	4	Perspective drawing
	5	Two-dimensional design—composition in lines
	6	
	7	Two-dimensional design—composition in shapes
	8	
	9	Two-dimensional design—composition in shapes and textures
	10	
Spr. 1st Yr. Intro. to Arch. Anal. Geom.	1	Three-dimensional design—folded paper in plane form
	2	Three-dimensional design—folded paper in form with depth
	3	Three-dimensional design—pressed paper in spatial and structural study
	4	Three-dimensional design—any material in spatial and structural study
	5	
	6	Three-dimensional design—study of inter-related transparent and opaque planes
	7	
	8	Three-dimensional design—study of space composition in planes involving open and closed forms
	9	
Fall 2nd Yr. Calculus Physics	1	Simple planning and function—a kitchen—interior only
	2	
	3	Simple planning and function—a guest cottage—interior and exterior
	4	
	5	
	6	Resolution and composition of forces
	7	Resolution and composition of forces
	8	Analysis of a truss
	9	Analysis of a truss
	10	Analysis of a truss

Supporting Subjects		Courses in Design		
		Architecture	Architectural Engineering	Building Construction
Wint. 2nd Yr. Arch. Hist. Calculus Physics Statics	1 2 3 4 5 6 7 8 9 10		None	
Spr. 2nd Yr. Arch. Hist. Mech. of Mat'ls Calculus Physics	1 2 3 4 5 6 7 8 9 10		Design using rustic materials—resort building Working drawings for resort building Analysis of forces in three dimensions Analysis of forces in three dimensions Topography and earth quantities Topography and earth quantities	
Fall 3rd Yr. Diff. Eq. Mat'ls & Meths. Structures Surveying	1 2 3 4 5 6 7 8 9 10		Specifications Estimating Structural design—roof framing only for small, wall bearing assembly building—wood	
Wint. 3rd Yr. Concrete Elec. & San. Equip. Mat'ls & Meths.	1 2 3 4 5 6 7 8 9 10		Structural design—framing for small building requiring only simple span construction—steel Design—small building of utilitarian character—suitable for development in later engineering problems	

Supporting Subjects		Courses in Design		
		Architecture	Architectural Engineering	Building Construction
Spr. 3rd Yr. Heating Mat'ls of Engr.	1		Structural design—framing for above building—concrete—introduction to indeterminate analysis	
	2			
	3			
	4		Working drawings—for above building including structural features	
	5			
	6			
	7		Electrical design—for above building	
	8			
	9		Plumbing design—for above building	
	10			
Fall 4th Yr. Elems. of Indet. Strs. Structures	1		Structural design—a mill building, superstructure only—principal frames developed in both three-hinged and two-hinged forms	
	2			
	3			
	4			
	5		Heating and ventilating design—for building from Winter of 3rd year	
	6			
	7			
	8			
	9			
	10			
Wint. 4th Yr. Prof. Prac.	1		Structural design—a multi-story building of simple plan—detailed consideration of problems of indeterminacy with especial reference to horizontal loading—concrete	
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
Spr. 4th Yr. Structures	1	Design—a public building of considerable complexity—most recent, a convention building	Structural design—a retaining wall, designed as both cantilever and counterfort	
	2			
	3			
	4		Structural design—collaborative study with architectural students—students paired in architect-consultant relationship	
	5			
	6			
	7		Financial study—economic factors affecting building decision	
	8			
	9			
	10			

You will see that the first four quarters are identical for all three curricula in so far as the major elements of the work are concerned. The greater part of this is the material usually offered to students in Architecture but the faculty members who conduct it have been very effective in assuring that its application to all three curricula is made clear. Its principal value for the Architectural Engineering students probably lies in an increased understanding of architecture and architectural thought. But we have found that the work in the Spring quarter of the first year has made a very considerable contribution to their insight into the nature and behavior of structures and, also, to their ability to visualize three-dimensional constructions. This work is the especial hobby of one of our teachers. The entire quarter is devoted to building three-dimensional constructions of common materials including paper, thread, toothpicks, and sheet plastic. In all the exercises, the ability to carry load is emphasized along with the aesthetic properties—the two are coordinated—and the students are required to study the appropriate shapings of these materials to achieve maximum strength.

Starting with the Spring of the second year, the Architectural Engineering students begin the series of problems designed to develop their especial interests. The nature and development of this work is readily understood from the chart. We have tried to conduct as much of it as possible in relation to realistic building problems in order to draw the students' attention to the associated problems in architectural design and in construction practice. We have not been entirely successful in maintaining this relationship but you will see that the first half of the Spring quarter in the second year covers a fairly well rounded problem. All of the work in the Winter and Spring quarters of the third year and a part of that in the Fall of the Fourth year are concerned with a single building. We hope that by such means we are leading the students to a broader view of their profession and its relation to others.

In the Spring of the fourth year we have introduced four weeks of work in which the students in Architecture and those in Architectural Engineering actually collaborate on a single project. We would like to introduce more of this but we find that students at lower levels have not enough competence in their own fields to be able to make contributions to each other's thinking. Also, it is very difficult to introduce new engineering concepts to the students while they are preoccupied with the difficulties of this work and we find that, although it is valuable training in the architect-consultant relationship, it is not very efficient instruction in purely engineering matters. Hence, the time available will not permit extension of this sort of teaching.

Annual College-Industry Conference Relations with Industry Division

January 26, 1956 Marquette University

The theme of the conference will be "Humanities and Engineering." The panel discussions will include the place of humanities in research, design or development, sales engineering, and manufacturing operations.

A Method of Teaching Leadership to Engineering Students

By REYNOLD K. WATKINS

Associate Professor of Civil Engineering, Utah State Agricultural College

Engineering educators point proudly to the high percentage of their former students who are called to executive positions in industry. Apparently, something about the technical training of an engineer prepares him for leadership. Perhaps it is the engineering approach to the solution of problems. From the beginning of his training, the engineer is taught to collect all available data, to draw a diagram, and to reason through to a logical conclusion. Fortunately this fundamental process is susceptible of general application to problems of policy level as well as to problems of a technical nature. Other types of education may emphasize examples and cases by the volumes, big formulas to grind, or facts and statistics; but these tools, like an awl in the hand of a cobbler, are generally limited in function. They can seldom solve a problem in policy or generic planning.

Many engineering executives declare that they have gained positions of responsibility in spite of rather than because of any direct attempt by their teachers to prepare them for leadership. Indeed, some executives feel that engineering education stunts growth in leadership because of heavy assignments which take all of the student's time, and because of the emphasis which teachers place on technical achievement. Whether or not this statement should be accepted without qualification, the general point suggests that something should be done to better prepare engineering students for eventual leadership.

To most of us, leadership means the authority given one person to direct the activities of others. Accordingly, a prospective leader may suddenly find himself in the role of a project director with an assignment to be the boss and get the job done. The primary difficulty is that the newly created boss does not know how to direct men, and can use only a few techniques that he has seen his own boss use before him. His position is worsened by the psychological makeup of the modern-day, free-thinking laborer. If the young leader fails to get the job done, he is relegated to the ranks of the subprofessionals or to a position in research or detailing; he is left here until another opportunity may arise for him to prove himself a leader. Under this authoritarian type of leadership, he can rise to a position of leadership only by appointment, but he can gain no appointment unless he can lead. Surely something is wrong. Maybe leadership needs a different definition.

Theory of Leadership in Small Groups

In recent years, many of America's outstanding sociologists have turned their attention to the social dynamics of small groups of individuals, a science popularly known as Group Dynamics. Some new concepts of leadership have come from this science. One of the more productive concepts has been proposed by Cattell, who reasons that leadership in its most effective form is a product of the group. This means that the group leadership is not necessarily vested in one person, a chairman, and that all the others are followers. Any group of individuals within

a very few minutes develops a kind of group personality called syntality. If the syntality of the group remains constant, there is no evidence of leadership. However, if the syntality changes as the group works or plays together, then leadership is manifested. Leadership might be defined, therefore, as the change in syntality of the group. A leader is anyone who in any way contributes to that change in syntality. He need not necessarily be the chairman. More likely than not, a formal organization having a chairman tends to suppress rather than encourage the spontaneous changes in syntality that group members are able to contribute. An example follows.

Usually the officers in student engineering organizations receive explicit instructions from their faculty adviser about conducting the activities of their organization. This year when the adviser met with the student officers the first time, he sat informally with them and after making one or two suggestions to provide some direction, he turned the problem over to the students. It took a few minutes plus a few jokes to put them at ease, but soon they commenced to make suggestions for their own chapter program. Each idea suggested others, and before the meeting was over the student program had been completely "brainstormed." The ideas finally adopted were much better than usual. Field trips and special events were planned that never had been thought of before. The excellence of the plan plus the enthusiasm of the student officers gave the adviser assurance that the program would be carried out successfully.

It does not follow that leadership always results in good. For example, the total change in syntality may tend toward discouragement; then the group may not even attempt to solve its problems or to play its game. Such a state of frustration might arise as to result in dissolution of the group. Frustration often results from non-participation of one or more members, or from disagreement among the members. In student engineering groups, though, the disagreement is a minor concern; for if sufficient time is allowed for solving the problem, the correct point of view usually can be demonstrated. The greatest danger to the group then remains the danger of non-participation. The non-participant may simply be shy, or he may be antagonistic; however, any normal participant not knowing the attitude of the non-participant is likely to assume the worst and then feels inhibited in his own participation. From the foregoing discussion:

1. Leadership is defined as change in syntality of the group or team.
2. Leadership in its most effective form must arise spontaneously from all members of the team; non-participants inhibit leadership.

Effectiveness of the Team as a Dynamic Group

Since the purely authoritarian type of leadership illustrated in the beginning seems to be losing its effectiveness with the modern American laborer, one might inquire under what conditions the worker does respond to leadership. If these conditions are found, then possibly a method can be developed for isolating and measuring leadership. One set of conditions under which the worker usually responds is teamwork, a spirit of which is strongly planted in the hearts of American youth through a wide variety of team contests. It is easily recognized that the team concept satisfies the two statements of leadership above. Surely the development of team spirit manifests an increase in syntality of the group. Surely the leadership is supplied in varying amounts by *all* members of the team; and of course the team fails if one or more members refuse to participate. It appears quite natural that American love for the team could provide an energizer for development of leadership within a small group. The necessary elements are the team, a problem to be solved or a lesson to be learned, and a reason for doing it.

The team spirit idea was tried by the author in a Contracts and Specifications

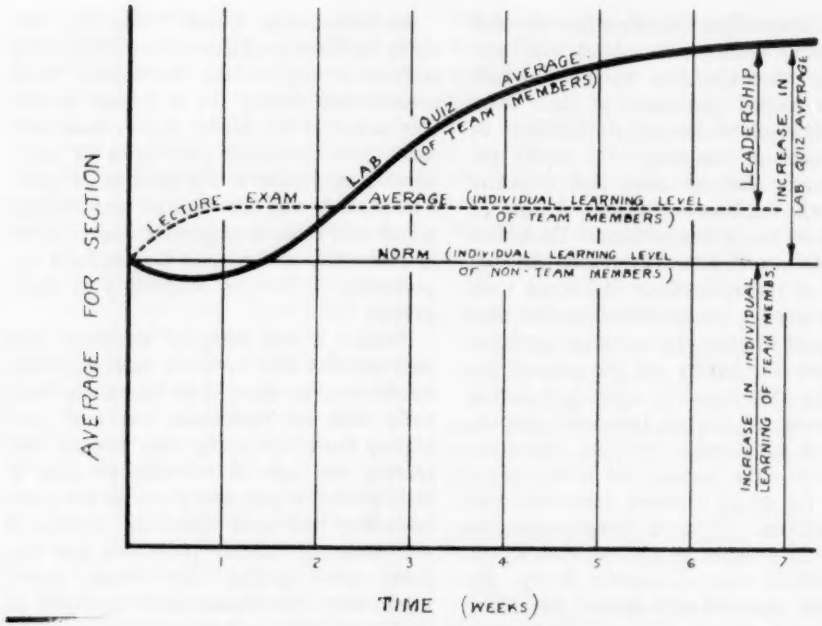
course. Several periods were first devoted to learning some facts about law and contracts; then the class was divided into five-man teams. Members of each team became the sole and equal stockholders in an engineering company. Of course the stockholders had to meet and organize their own engineering firm. A list of their assets was given to them. Each firm was made responsible for writing its own articles of incorporation. All firms were then assigned a construction project, and were asked to draw up necessary contract documents for letting out the project for bids. In this capacity each engineering firm was agent for an imaginary owner. The next assignment inverted the situation; each firm became the bidder on a project for which contract documents had been written. In both assignments the firms were competing against each other. The bidding was extremely lively, for bids were received and opened according to usual procedures. The actual minimum cost of the hypothetical project had been calculated previously by the instructor, and bids were thrown out as a penalty for bidding dangerously below cost. The lowest bidder above minimum cost won the most credit on the bid submitted, provided the form was acceptable. Next lowest bidder was second in credit, etc. Enthusiasm of the class was much better than it had ever been before in Contracts and Specifications. Although measurement of the quality of the work in comparison to that done in other years was difficult, the results seemed generally superior. Certainly grades on examinations were better. The group dynamics approach had proved a superior educational technique.

Team Dynamics Develops Leadership

The above example demonstrates the effectiveness of group dynamics through problem-solving teams and proves the power of the team to raise the learning level in certain college courses; but it does not indicate that the raise is due to leadership in the teams.

An attempt to isolate leadership was made in three problem-solving laboratory sections in Engineering Mechanics. Each section met weekly for a 3-hour period. The object of the course was to teach students how to apply principles of engineering mechanics to the solution of problems; but it was felt that an opportunity might also exist to suggest a few pointers in leadership and to give the students opportunity to develop leadership in small groups.

Section A was assigned problems that each student had to solve independently. Students were allowed to consult individually with the instructor, but were prohibited from consulting with anyone else. During the last 30 minutes of each 3-hour period, a quiz was given on the problems they had been studying. Section B was assigned similar problems, but students were divided into 3-man teams. Each week the teams were changed so that every man had opportunity to work with every other man in his section. The last 30 minutes of the period was devoted to a quiz on the problems. Section C also was assigned problems, with a quiz at the end of the period, but the men were allowed to work in teams of their own choosing. Once the team was set up, it became permanent for the duration of the course. Section A was considered norm. At the end of the course the quiz average for Section B was 12% higher, and the average for Section C was 39% higher than the norm. These results were weighted to eliminate variations in group capabilities. Variations were determined by a 4-week period at the beginning of the course when all students worked independently as described for Section A. It is noteworthy that the temporary groups in Section B did not develop into the successful problem-solving teams that the permanent groups in Section C developed into. The results of these lab quiz averages for each section were plotted on a graph of lab quiz average versus time in weeks. In this experiment the results were rough and erratic, but the general trend for Section C is



shown on the figure. Again the results show that use of group dynamics raises the learning level, but in this experiment it was assumed that part of the increase in lab quiz average resulted from leadership within the team—not just an increase in individual learning. One would expect that increase in individual learning would occur as the students check each other's answers, compare methods of solution, and instruct each other. A plot of individual learning in the group versus time would be expected to rise suddenly and remain constant as shown by dotted line on the diagram. This curve was evaluated by giving a series of exams during lecture to the combined sections. Those students who had been members of teams clearly had a higher lecture exam average, as shown by dotted line, but the increase was very small in comparison to that of the lab quiz average. The major part of the increase in lab quiz average, then, must reflect a substantial increase in the ability of the team (not the individual) to solve problems. This increase is precisely a change in syntality of the group and therefore can represent nothing else than leadership. Put into a formula, leadership is measured by the increase in lab quiz average minus the increase in individual learning. Typical values are indicated on the diagram. It is interesting to note that the group leadership develops slowly at first; in fact, it is virtually negative the first week when the members are learning how to react to each other in the team situation.

Part the Instructor Plays

The instructor can hardly determine which students are benefiting most from this development of leadership. Surely he could not give each man a grade in leadership on the basis of these results. Nevertheless, the very fact that somebody is developing leadership is valuable to engineering education.

The time may come when sociologists can prescribe more powerful methods for applying Group Dynamics. When such a time comes, the engineering teacher may be able to outline principles and techniques so that all students may launch immediately into successful group problem-solving situations. Even without a

perfect understanding of Group Dynamics, there are a few things a teacher can do to prepare students for group experiences. He should warn against authoritarian organization of the group because such organization stifles spontaneous leadership of the members. He must insist that all members of the group participate. Finally he can supply incentive and direction for the teams as they seek their problem-solving goals. Incentive may or may not be in the form of competition.

If engineering educators would adopt group dynamic or team methods under appropriate circumstances they would not only realize an increased level of individual student learning, but they would greatly stimulate leadership development. The extent to which spontaneous leadership within a team can prepare an engineer for formal leadership of industrial firms can be determined only after a fair trial; but even with partial success, the future leaders of American industry would be deeply grateful.

Publications Available

EDUCATIONAL AIDS FOR ENGINEERING

Prepared by the Teaching Aids Committee of the ASEE, a catalog listing more than 5000 teaching aids in the fields of mathematics, mechanics, civil, mechanical, and electrical engineering is again available. It describes 290 devices which were rated by the ASEE reviewing committees as the best available for engineering education; examples include a television demonstrator to supplement the teaching of communications, circuits, and electronics, a hydraulic demonstrator which illustrates various phases of fluid mechanics, 16 mm. motion pictures and 35 mm. film strips, plus other simple and ingenious ways to dramatize learning. The catalog explains the principle and nature of each aid, equipment necessary, where the equipment can be obtained, and costs. The spiral-bound volume, at $1.00 per copy, is 8½" by 11" and has 72 illustrated and indexed pages. Orders should be sent to the ASEE Office, University of Illinois, Urbana, Illinois. Send for one today!

ILLUSTRATIVE PROBLEMS IN ENGINEERING

A source of typical engineering problems and examples in Dynamics, Elasticity, Electricity and Magnetism, Electronics, Fluid Flow, Heat Transfer, Materials, Statistics, Systems, and Creative Ideas is now available in General Electric's new inch-thick volume, *Illustrative Problems in Engineering*. Compiled by the Company's Engineering Training and Education Section, the problems are those which students are likely to encounter in industry, but which are frequently omitted from textbooks and are not readily available to engineering instructors. This hard-backed volume is separately paged by topics and is available to members of college faculties. Write to: Engineering Recruiting Section, General Electric Company, One River Road, Schenectady, New York.

GRAPHICAL SYMBOLS FOR PLUMBING

A new American Standard Graphical Symbols for Plumbing has been developed by the ASA Sectional Committee on Standardization of Graphical Symbols and Abbreviations for use on Drawings, and approved by the American Standards Association. Copies may be obtained from The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, New York.

Report of the Engineering School Libraries Committee, 1954–55

By J. H. MORIARITY

Director of Libraries, Purdue University

The Committee carried on considerable inter-member contact and made one general mailing to librarian members in the Northeast states. There were regional meetings of the librarian members, but reports of only two such meetings reached the Chairman. More close check of such activity will be made in 1955–56.

The Annual Meeting offered an opportunity to hold two meetings. A luncheon business meeting was useful as such, but actually turned into an advisory panel of the librarians in order to help two instructors who joined the luncheon. These instructors presented local institutional problems of a library nature which were worrying them in connection with their teaching. Considerable advice of a worthwhile nature was given to them.

The two papers presented at the open meeting, June 23, were:

1. Information Searching Habits of Engineers and Scientists. Saul Herner, Atlantic Research Corp.
2. Scholarly and Professional Library Experiences. Thomas J. Higgins, University of Wisconsin.

The presentation was excellent and the discussion among the twenty librarians at the meeting continued until past 4 P.M.

Teaching Salaries Then and Now

Under the auspices of the Fund for the Advancement of Education established by the Ford Foundation, Beardsley Ruml and Sidney G. Tickton have recently completed an economic investigation of teaching salaries over the past fifty years. Their comprehensive study is summarized in the new 93-page, 6″ by 9″ bulletin Number 1, *Teaching Salaries Then and Now*. Rather than telling what teaching salaries should be, the bulletin clearly reveals how these salaries stand today in relation to incomes in other fields. This discussion-provoking report can be obtained from the Fund for the Advancement of Education, 655 Madison Avenue, New York 21, New York. The report will be of considerable value to teachers and administrators alike.

The Engineering Economist

The Engineering Economy Committee of the ASEE announces its quarterly publication, *The Engineering Economist*, devoted to engineering economy and related fields. The publication implements the work of the Economy Committee by publishing original articles, papers presented at the annual meeting of the Committee, reprints of articles appearing in other publications, book and speech reviews, reports on problems involving economics in engineering, critical comments, and exchanges of ideas. To ASEE members subscriptions are $1.50 per year for four issues, and to nonmembers $2.00 per year. Single copies are 75 cents. Subscriptions may be addressed to: Box L, *The Engineering Economist*, Stevens Institute of Technology, Hoboken, New Jersey.

Report of the Auditor

September 27, 1955

Executive Board
American Society for Engineering Education
Urbana, Illinois

Gentlemen:

In accordance with your instructions we have made an audit of your records for the year ended June 30, 1955, and herewith submit our report, consisting of a balance sheet and the related statements of income and expense and of changes in account balances. Our examination was made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

Following past practice, inventories of Society publications are not included in the balance sheet. The costs of publication have been charged to operations in the year of printing.

In our opinion, the accompanying balance sheet and statements of income and expense and of changes in account balances present fairly the financial position of the American Society for Engineering Education at June 30, 1955, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Respectfully submitted,

(Signed) FILBEY, FILBEY & BEAGLE,
Certified Public Accountants

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Balance Sheet

June 30, 1955

CURRENT FUND

ASSETS

Cash:		
Checking accounts	$15,888.54	
Savings accounts	25,405.12	$41,293.66
Petty cash		300.00
United States Government obligations at cost, plus accrued interest of $93.75		46,793.75
Accounts receivable:		
Advertising	$ 2,920.01	
Dues	1,800.00	
Westinghouse Education Foundation	257.23	
Due from B. J. Lamme Fund	305.07	5,282.31
Unused advances to Humanistic-Social Research		2,550.78
Deposit for air travel card		425.00
Office supplies		210.00
Inventory		1.00
Furniture and equipment		1.00
Total Assets (NOTE)		$96,857.50

LIABILITIES AND SURPLUS

Accounts payable and accrued expenses		$14,133.68
Dues collected in advance		656.65
Excess of contributions over expenditures (NOTE):		
Educational Aids	$ 2,392.07	
Evaluation of Engineering Education	8,393.12	
Humanistic-Social Research	8,214.03	18,999.22
Surplus:		
Reserve for special projects	$ 5,317.19	
Reserve for ECRC	5,093.93	
Unappropriated surplus	52,656.83	63,067.95
Total Liabilities and Surplus (NOTE)		$96,857.50

B. J. LAMME FUND

ASSETS

Cash	$ 290.25
Income cash in hands of trustee	290.70
Principal cash in hands of trustee	5.51
Securities and mortgages	10,136.22
Total Assets	$10,722.68

LIABILITIES AND SURPLUS

Due to current fund	$ 305.07
Surplus	10,417.61
Total Liabilities and Surplus	$10,722.68

NOTE: As of June 30, 1955, $18,999.22 of the total assets of $96,857.50 represent amounts received from outside organizations to be used for special projects. These amounts are not available for general Society operations.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Statement of Changes in Account Balances

For the Year Ended June 30, 1955

CURRENT FUND

Educational Aids

Balance, July 1, 1954		$ 6,767.51
Deduct:		
Expenditures	$ 3,250.44	
Income from teaching ads for the year ended June 30, 1954 transferred to unappropriated surplus	1,125.00	4,375.44
Balance, June 30, 1955		$ 2,392.07

Evaluation of Engineering Education

Balance, July 1, 1954	$ 5,012.45
Add:	
Contributions	13,000.00
Total	$18,012.45
Deduct:	
Expenditures	9,619.33
Balance, June 30, 1955	$ 8,393.12

Humanistic-Social Research

Balance, July 1, 1954	$20,457.15
Deduct:	
Expenditures	12,243.12
Balance, June 30, 1955	$ 8,214.03

Reserve for ECRC

Balance, July 1, 1954	$ 6,430.19
Add:	
Sale of ECRC publications	336.28
Total	$ 6,766.47
Deduct:	
Excess of ECRC expense over the budgeted amount	1,672.54
Balance, June 30, 1955	$ 5,093.93

Unappropriated Surplus

Balance, July 1, 1954		$46,829.86
Add:		
Net income for the year ended June 30, 1955	$ 4,701.97	
Income from teaching ads for the year ended June 30, 1954 transferred from educational aids	1,125.00	5,826.97
Balance, June 30, 1955		$52,656.83

B. J. LAMME FUND

Surplus

Balance, July 1, 1954	$10,316.06
Add:	
Income	327.14
Total	$10,643.20
Deduct:	
Expense	225.59
Balance, June 30, 1955	$10,417.61

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Statement of Income and Expense

For the Year Ended June 30, 1955

		Actual	Budget	Difference Favorable (Unfavorable)
Income				
Individual dues		$49,652.40	$49,100.00	$ 552.40
Institutional dues		12,537.00	12,000.00	537.00
Sale of publications		4,010.23	2,800.00	1,210.23
Advertising		20,629.20	20,000.00	629.20
Teaching ads		735.88	—	735.88
Interest income		1,404.62	780.00	624.62
ECRC	$ 336.28			
Less amount credited to the reserve for ECRC	336.28	—	—	—
Refund from annual meeting		357.28	—	357.28
Miscellaneous		1.24	—	1.24
Total Income		$89,327.85	$84,680.00	$ 4,647.85
Expense				
Annual meeting		$ 2,351.32	$ 3,000.00	$ 648.68
Journal and *Proceedings*		32,343.35	30,000.00	(2,343.35)
Committees and conferences		612.69	2,000.00	1,387.31
Postage and telephone and telegraph		2,942.20	2,500.00	(442.20)
Supplies, expense and sundry printing		5,319.89	4,500.00	(819.89)
Travel expense—secretary's office		1,994.19	2,000.00	5.81
Officers' travel expense		3,061.21	3,000.00	(61.21)
ECAC		498.14	2,200.00	1,701.86
ECRC	$ 6,022.54			
Less amount charged to the reserve for ECRC	1,672.54	4,350.00	4,350.00	—
Administrative salaries:				
Secretary	$ 7,962.50			
Assistant secretary	3,240.00			
Office secretaries	12,207.89			
Clerical assistance	299.43	23,709.82	23,500.00	(209.82)
Retirement of emeritus assistant secretary		1,360.00	1,360.00	—
Bonding fees and auditors		924.70	375.00	(549.70)
Dues (American Council on Education)		200.00	200.00	—
ECPD (contribution)		500.00	500.00	—
Contingencies and special projects		927.34	2,000.00	1,072.66
EJC dues		573.00	700.00	127.00
Moving		1,384.85	—	(1,384.85)
Utilities		233.55	—	(233.55)
Furniture		1,314.71	—	(1,314.71)
Refunds		24.92	—	(24.92)
Total Expense		$84,625.88	$82,185.00	($ 2,440.88)
Net Income		$ 4,701.97	$ 2,495.00	$ 2,206.97

NOTE: The statement of income and expense reflects the general Society operations. Contributions received and expenditures made in connection with the special projects listed in the balance sheet are not shown in this statement.

Candid Comments

Grading of Exams

By RALPH H. UPSON

Professor of Aeronautical Engineering, University of Minnesota

Professor Sanks' interesting paper on this subject in the March JOURNAL brought out some worthwhile aims, to which no one should object. Examinations should certainly be interesting and instructive, as well as revealing. His eloquent plea for raising the standards of individual responsibility should be heeded by all. Yet, his first conclusion is of questionable validity as implying the necessary means to these ends. His advocacy of no credit for inaccuracies, as interpreted by the context, apparently means to grade entirely on the basis of an accurate numerical answer, with zero credit for the entire problem otherwise. Granted, that individual responsibility on the part of the student is one of the most important characteristics to develop; still it should seem obvious, even to a student, that there are other factors than numerical accuracy involved; and one of the best means of developing responsibility in the student is the example of a teacher willing to go to the necessary trouble to evaluate the various interrelated factors of which a good examination paper is composed.

Recently this same article came up for discussion in a small group composed of four professors and four scientists, two of the latter from industry. The opinion was unanimous that accuracy is not all-important, especially on the undergraduate level. An engineering representative from one of the leading aircraft manufacturers brought out that anyone can make a mistake, regardless of how well trained and how high his sense of responsibility. Therefore, all important quantitative results and equations *must* be independently checked, as witness no less an authority than the late Dr. Einstein. Numerical checking is fairly simple with modern computing machines. Furthermore, most engineering data, criteria and formulas are inherently inexact, and there is no point in carrying the end results to a disproportionate accuracy. For many purposes of preliminary design, an accuracy within 15% is all that can be expected or desired. Here, sound thinking and resourcefulness are far more important than accuracy. From the professors' group, the only advantage mentioned for the proposed system of grading was that it is certainly easier for the teacher. In this and other respects, it would seem to be in a similar category with the equally reactionary but still controversial closed-book examination. The combination of both these features is of course nothing new, but represents the most primitive type of examination, the kind which now can be graded by machine. Or, as one conservative remarked, "That's not engineering; that's bookkeeping."

Coming back to present students' papers, a proposed method of improving the fairness of the credit-for-accuracy-only type of test is subdividing a problem into a number of parts. It is apparent that with sufficient subdivision and with no more than one penalty for the same mistake, the two systems would be really the same in effect except for the varying seriousness of possible mistakes.

It is easy to say we want accuracy, and nothing else will count; but there are many kinds and gradations of errors, ranging from the trivial to the fantastic. To name but a few:

1. Slide rule inaccuracy.
2. Omission of an unimportant factor such as $(1 - \mu^2)$.
3. Omission of an important factor such as 2 or $\frac{1}{2}$.
4. Misplacing the decimal point.
5. Failure to convert inches to feet or vice versa.
6. Units or direction omitted.
7. Use of engineering resourcefulness to reach an approximate answer.
8. Realization that the answer is incorrect.
9. Answer correct but procedure not clear.
10. Misunderstanding of question.
11. Correct procedure but ran out of time.
12. Correct use of erroneous answer to one problem to solve another.
13. Lack of judgment in using erroneous data from book or notes.
14. Application of a semi-empirical method to a questionable range of conditions.
15. "Formula snatching"; total misapplication of a formula.

Does Mr. Sanks mean to imply that any or all of the above errors should be treated with equal ruthlessness, denying all credit for the problem involved? Based on his experimental course procedures, about the most credit that he would ever consider for sound theory is one-half, and he opposes even that. Personally I mark on the basis of *deduction* for errors, with never more than 10% penalty for an individual arithmetical error unless the student should have been able to see by inspection the absurdity of his result. In the case of item 7, I impose no penalty whatever if the resourcefulness is judged to balance the error, because under no circumstance should the student be discouraged from original thought.

If it can be conceded that training in resourcefulness, original thinking and intellectual honesty are primary objects in an engineering course, it is hard to see how they can be encouraged by mere insistence on numerical accuracy of answers which, by the nature of the case, makes almost mandatory the use of a standardized procedure. It is also hard to see how the several problems with careful checking of each, advocated by Mr. Sanks as requisite to his system, can be crowded into a two hour examination, let alone the fifty minutes available for frequent tests during the course, and still leave time for original thought.

To quote a complaint from one of my students several years ago, "Professor Upson expects us to think and we haven't time to think." As a means of providing time for such thought, let us not overemphasize numerical accuracy, important as it is, but realistically admit that the undergraduate student has other important things to learn, one of them being a recognition of human frailty in general, as so often exemplified in the pronouncements of teachers, Mr. Sanks' provocative article included.

Why be an Instructor?

By MARTIN LEVINE

As a new instructor, I attempted adequately to answer this question. It is now my intention to present the problem, as I see it, without supplying the answer, which as yet I have not obtained. Most readers are acquainted with the difficulties in obtaining qualified instructors. Most of you have in mind both the advantages and disadvantages of the teaching profession. It is my intention to

review carefully the major advantages and disadvantages to teaching engineering.

On the side of disadvantages, the subject of salary looms as the largest and, to many, the only problem. In order to adequately maintain a suitable standard of living for his family, an instructor must resort in many instances to a second job, university research project, or a reduced standard of living. In compensation for low salary, increased leisure is often cited. To the good instructor such leisure is a fiction; for even if he were financially secure, which most are not, he must consume a large number of hours aiding the inferior students and challenging the superior ones. It is frequently implied or stated that as teaching becomes repetitive it will not require as extensive a preparation. It shall then become necessary in my opinion, for the good instructor to devote the additional free time to aiding the poorly equipped students in the mastery of the subject.

An advantage often cited is the prestige in teaching. In the present day American society, which is a highly materialistic one, the earner of the largest income receives the greatest ovations. The number of eulogies to good instructors are insignificant to the number for entertainers in the fields of radio, television, movies and sports. The prospect of preparing a textbook for not only the pecuniary return but also the added prestige involved in such an undertaking is frequently mentioned. The unavailable time, if suitable instruction is desired, and the need in most cases to hold professorial rank to have a book become acceptable to schools in general makes this idea unsuitable for the general instructor.

The moral obligation to society is stressed frequently. Forgotten is an instructor's obligation to his family and the further fact that the American society in many cases ignores moral obligation when financial award is present. An individual who becomes an instructor must devote a large part of his time to a secondary occupation in order to have the wherewithal to maintain a living standard in his community equal to that of other professional people. In order to obtain instructors at the low salary scale, in many instances, marginal instructors are employed, instructors who work on a part time basis, instructors that devote time to secondary employment and the use of instructors on research assignments which in no way enhance instruction at the undergraduate level. At the university level, use of graduate students for undergraduate instructors is employed to the detriment, in my opinion, of the average technical student, since the graduate student is not interested in teaching as an occupation. In the graduate school, close association with a professor on a research project alleviates some of this difficulty, but not all, since in many cases the research is the end desired rather then the student's education.

In my limited personal contact with the subject I found no suitable incentive for an instructor to be just a good instructor. Salvation is spiritual and this may not, and usually does not, satisfy his family demands upon him. The number who can overcome the financial obstacle are few and far between. I am proposing no solution here, but rather presenting the problem for open discussion. A look at job opportunities offered to engineering students just graduating shows a salary average of approximately $4800.00 per year compared to an instructor of engineering who on a 9-month basis receives approximately $4000.00 and on a 12-month basis on the average receives $5000.00, reference: *faculty salaries in land-grant colleges and state universities*, 1951–52, Circular No. 358, U. S. Department of Health, Education, and Welfare: Office of Education.

An engineering analysis considering the economic, financial, intangible factors in being an instructor would show in an "In-Favor Analysis" that an incentive of some type is necessary to attract the best instructors to the teaching profession, rather than mere platitudes.

National Engineers' Week

(Week of Feb. 19, 1956)

National Engineers' Week is an effort to acquaint the public with facts about the engineering profession and the role it plays in our national welfare. To be most effective, this information must be presented in a dramatic, interesting, and stimulating manner, trying to reach all possible channels of public information and all segments of the American people.

A profession cannot fully carry out its fundamental obligation of public service if the public is not aware of the many ways in which the profession can be of service to them. It is, therefore, one of the duties of a profession to keep the public informed as to what the profession does and how it affects everyday life. In the case of such professions as law and medicine it would seem hardly necessary to explain their functions to the public. These professions are well known because long ago they realized the need for establishing good public relations and they have carried on appropriate and successful programs of public information. The American Bar Association, the American Medical Association, and their state and county units still continue this work and regard it as one of their most important functions.

Because of its division into numerous technical societies, the engineering profession as a whole has never undertaken a program to make its functions known and appreciated by the public. Yet in these days, more than ever before, it is becoming essential for our profession to do so.

The struggle for the survival of the free world is largely a technological struggle in which the professional engineer plays a vital and indispensable role. Continuance of our way of life is dependent upon maintaining our position of technical supremacy, which demands the highest quality of technical ability. To maintain America's present leadership, it is essential that we attract the most talented, the most creative minds of our young men and women to engineering and scientific pursuits.

It has been truly said that the finest youth are attracted to that profession to which their country attaches most prestige. In totalitarian countries, a few men can decree which profession shall have such prestige. Behind the "iron curtain," strong incentives are offered to young men and women to follow engineering and scientific careers. In a free country like ours, we must attain the same result by selling the idea that the building up of the prestige of the engineering profession is the patriotic duty of every member of our profession. This can be done most effectively by a continuous program of public information.

Cold facts and statistics lack in public appeal, and are not readily assimilated. To impress the public with the importance of our message and to do it quickly and effectively, we must dramatize factual information with emotional appeal, and present it with enthusiasm. National Engineers' Week affords the opportunity for such presentation.

An eminent engineer recently wrote:

"The great American public is quick to appreciate ability. And I have found that the public does recognize the engineer in thinking that he can do just about everything there is to be done. But the public

sees only the completed product; it does not appreciate the engineer's part in it. It is as if the fans knew only the score of the ball game after it was finished. If the public could intimately see and understand the hits and runs and errors of the engineer as he works to perfect his product—to complete his ball game—its appreciation would be boundless for the wonders he performs.''

We can feel justly gratified with the growing response of the profession to the public service programs of National Engineers' Week. Joint participation in such programs by various engineering and technical societies demonstrates to the public the essential unity of the engineering profession.

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Teaching Positions Available

ASSISTANT OR ASSOCIATE PROFESsor (rank depends upon training and experience) to teach Engineering Drawing and some courses in Industrial Engineering. Nine months basis with possibility of one term Summer School. Opening February 1, 1956. Location, Southwest. DEC–1

TWO INSTRUCTORS ENGINEERING drawing preferably with degree in some branch of engineering, but degree in Industrial Arts will be considered. Teaching period is nine months with possibility of some six week summer school term. Opening February 1, 1956. Location, Southwest. DEC–2

INSTRUCTOR OR ASSISTANT PROFESsor to teach fundamental electrical engineering courses in Midwest engineering college. M.S. degree and/or teaching experience desirable. Position available January 1, 1956 or later. Good salary for qualified person. DEC–3

PROFESSOR (ASSISTANT, ASSOCIATE, or full rank). Candidate should have M.S. degree; experience with High Frequency very desirable. Teaching assignments: basic electronics, communications and fundamental electrical engineering courses. Rank and salary will depend upon experience and training. School location on a large campus in northwest Detroit. Cooperative program. Position open for terms starting either November 20, 1955, or February 21, 1956. DEC–4

ASSOCIATE PROFESSOR, PH.D. DEsirable, M.S. essential, with teaching and professional experience in civil engineering, to teach graduate and undergraduate subjects in two subdivisions of civil engineering at Midwest university. Instructor or Assistant Professor, with Ph.D. degree or willing to work towards it, to teach principally undergraduate subjects in two subdivisions of civil engineering. DEC–5

ENGINEERING FACULTY OPPORTUNity at Midwest state college. The Chairman in the Physics Department, salary open. Electrical Engineering Instructor or Assistant Professor in the Power field. Mechanical Engineering Instructor or Assistant Professor in Physics. Opportunity for graduate study. Housing available. Positions start September, 1956. DEC–6

ASSISTANT PROFESSOR AND INstructor at small Midwest engineering college in department of Civil Engineering. Positions for spring or fall semester 1956–57. Assistant professor must have special training or experience in sanitary engineering. Must have broad interest as applied mechanics and strength of materials as well as civil engineering are taught. Graduate studies available at nearby university. DEC–7

ASSISTANT AND ASSOCIATE PROfessor in dual teaching positions in Electrical Engineering. Applicants are particularly desired from interest in power, servomechanisms, or computers. Write resume of educational background and experience to Dean Ralph G. Galbraith, College of Engineering, Syracuse University, Syracuse 10, New York.

APPLIED MECHANICS AND CIVIL engineering teachers urgently needed to begin about January 26, 1956. Write J. H. Murdough, Head of Civil Engineering Dept., Texas Technological College, Lubbock, Texas.

STAFF OPENINGS IN CIVIL, ELECtrical and Mechanical Engineering; M.S. or Ph.D.'s desired. Salaries commensurate with qualifications. College of Engineering, Duke University, Durham, North Carolina.

HEADSHIP OF INDUSTRIAL ENGIneering Department open. Requires background of progressively responsible management positions in industry or government. Good record of publications. Research and teaching experience desirable. Age, 35–50; salary, open; position to be filled prior to September, 1956. Write Chairman, Nominating Committee, Industrial Engineering Department, The Pennsylvania State University, University Park, Pennsylvania.

INSTRUCTOR AND ASSISTANT PROfessor in Mechanical Engineering to teach Heat-Power subjects, Manufacturing Processes, or design. Opportunity to study for Graduate Degree. Salary depends upon qualifications. Associate Professor to teach and develop courses in the field of Metallurgy. Ph.D. degree and teaching experience desirable. Apply to Chairman, Department of Mechanical Engineering, University of Texas, Austin 12, Texas.

New Members

ALDEN, CARROLL RUSSELL, Associate Professor of Electrical Engineering, Ohio Northern University, Ada, Ohio. Lawrence H. Archer, Alton D. Taylor.

ASKOUNES, PERICLES N., Administration Chairman, Dealer Coop Program, General Motors Institute, Flint, Michigan. Harold M. Dent, C. A. Brown.

BARYLSKI, JOHN ROBERT, Assistant Professor, Mechanical Engineering, New Bedford Institute of Textiles and Technology, New Bedford, Mass. Howard C. Tinkham, Lenine Gonsalves.

BERENDS, HENRY EVERETT, Instructor of Mechanical Engineering, Bradley University, Peoria, Illinois. R. B. Gibbs, F. C. Mergen.

BRADFORD, JOHN R., Dean of Engineering, Texas Technological College, Lubbock, Texas, O. A. St. Clair, C. V. Bullen.

BURNS, HUGH, Instructor in Engineering Mechanics, New York University, New York, New York. F. L. Singer, C. Morris.

CAHN, CHARLES R., Assistant Professor of Electrical Engineering, Syracuse University, Syracuse, New York. Robert P. Lett, B. H. Norem.

CHOPPESKY, (REV.) JOHN CORNELIUS, Acting Dean, Regent of Parks College, Saint Louis University, East Saint Louis, Illinois.

CLIFFORD, LLOYD IRWIN, Instructor of Engineering, West Contra Costa Junior College, Richmond, California.

COMO, JACK, Assistant Professor of Mechanical Engineering, New York University, New York, N. Y. L. O. Johnson, A. H. Church.

COOK, WILLIAM H., Assistant Professor of Civil Engineering, Loyola University of Los Angeles, Los Angeles, California. D. E. Whelan, Jr., Fr. L. C. Werts.

COTTOM, MELVIN CLYDE, Assistant Professor of Electrical Engineering, Kansas State College, Manhattan, Kansas. E. L. Sitz, O. D. Hunt.

DAVISON, BEAUMONT, Instructor of Electrical Engineering, Syracuse University, Syracuse, New York. R. P. Lett, B. H. Norem.

DESFORGES, A. VANVRANKEN, Instructor in Civil Engineering, Union College, Schenectady, New York. H. W. Bibber, C. F. Goodheart.

DODD, LOUIS SMITH, Instructor of Electrical Engineering, Bradley University, Peoria, Illinois. R. B. Gibbs, F. C. Mergen.

EZEKIEL, FREDDIE D., Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. W. W. Murray, J. Kaye.

FELLERS, RUFUS GUSTAVUS, Chairman, Division of Electrical Engineering, University of South Carolina, Columbia, South Carolina. J. H. Noland, Jr., R. L. Sumwalt.

FLETCHER, LEONARD JAMES, JR., Assistant Professor of Industrial Engineering, Bradley University, Peoria, Illinois. F. C. Mergen, R. E. Gibbs.

GONSER, MARTIN E., Instructor of Industrial Education, University of Oklahoma, Norman, Oklahoma. E. F. Dawson, C. L. Farrar.

GROSVENOR, NILES E., Assistant Professor of Mining, Colorado School of Mines, Golden, Colorado. F. R. Campbell, L. J. Parkinson.

HEIMAN, DAVID WILLIAM, Director, Department of Military Art, The Engineer School, U. S. Army, Fort Belvoir, Virginia. W. N. Underwood, E. E. Packard.

HEIMER, ROGER C., Associate Professor of Mechanical Engineering, Villanova University, Villanova, Pennsylvania. J. S. Morehouse, J. J. Gallen.

HORN, TYREE R., Instructor, Pennsylvania State University Center, York Pennsylvania. E. M. Elias, V. E. Neilly.

HOUGH, CHESTER CARROLL, Instructor of Engineering, The Pennsylvania State University, University Park, Pa. V. E. Neilly, C. G. Mills.

JERDE, ROBERT S., General Personnel Relations Supervisor, Wisconsin Telephone Company, Milwaukee, Wisconsin. R. J. Panlener, A. B. Drought.

KRAFT, WENDELL EVERETT, Associate Professor of Engineering, Trinity College, Hartford, Conn. H. J. Lockwood, C. H. Coogan.

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LORD, G. ROSS, Professor of Mechanical Engineering, University of Toronto, Toronto, Canada. J. M. Ham, G. F. Tracy.

MA, BENJAMIN MINGLI, Assistant Professor of Mechanical Engineering, Ohio Northern University, Ada, Ohio. L. H. Archer, A. D. Taylor.

MARGOLIN, CHARLES H., Instructor of Industrial Engineering, Syracuse University, Syracuse, N. Y. B. H. Norem, R. P. Lett.

MINOR, BEN, Lecturer, Electrical Engineering, City College of New York, New York, N. Y. C. Froehlich, H. B. Hansteen.

MORGAN, BROTHER REGIS, Associate Professor of Mathematics, Saint Mary's College, Winona, Minnesota. E. G. Pare, I. L. Hill.

MUELLER, WHEELER KAY, Assistant Professor of Mechanical Engineering, New York University, New York, N. Y. A. H. Church, I. Wladaver.

MUNGER, HAMNETT PITZER, Chairman of Chemical Engineering, Syracuse University, Syracuse, N. Y. R. P. Lett, B. H. Norem.

MURDOCK, JOHN WASHBURN, Assistant T.A.M. Department, University of Illinois, Urbana, Illinois. J. O. Smith, C. E. Kesler.

MCKELVEY, JAMES M., Assistant Professor of Chemical Engineering, The Johns Hopkins University, Baltimore, Maryland. H. Hoelscher, R. H. Roy.

NORDQUIST, CARL GUNNAR, Associate Professor of Economics, Colorado School of Mines, Golden, Colorado. F. R. Campbell, W. M. Richtmann.

OERGEL, CHARLES THEODORE, Head, Department of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. J. R. Curreri, W. H. Ruten.

OTT, ERNEST JOSEPH, Assistant Professor of Civil Engineering, The Catholic University of America, Frederick, Maryland. F. Biberstein, P. J. Claffey.

POTHIER, MATHEW V., Assistant Professor of Civil Engineering, Ohio Northern University, Ada, Ohio. A. D. Taylor, L. H. Archer.

RAVILLE, MILTON EDWARD, Associate Professor of Applied Mechanics, Kansas State College, Manhattan, Kansas. F. J. McCormick, C. H. Scholer.

RYMERS, PHILIP CLARK, Instructor of Engineering Mechanics, University of Toledo, Toledo, Ohio. E. D. Harrison, W. S. Smith.

SAVAGE, CHARLES F., Consultant in Professional Relations, General Electric Company, New York, N. Y. M. M. Boring, H. W. Guildthorpe.

SHAW, RAYMOND NEWELL, Instructor of Civil Engineering, Kansas State College, Manhattan, Kansas, R. F. Morse, B. L. Smith.

STONEHAM, RICHARD G., Professor of Mathematics, University of California, Los Angeles, California. W. L. Collins, W. R. Woolrich

STUDNICKI, RAYMOND PAUL, Instructor of Industrial Engineering, Bradley University, Peoria, Illinois. F. C. Morgen, R. E. Gibbs.

TILLEY, ROBERT JAMES, Assistant Editor, Editorial Department, John Wiley & Sons, Inc., New York, N. Y. J. S. Snyder, W. G. Stone.

VANHORN, JOHN ROBERT, Director of Technical Training, Westinghouse Electric Corp., Pittsburgh, Pennsylvania. G. E. Moore, G. D. Lobinger.

VITTUCCI, ROCCO VICTOR, Standardization Planning Engineer, Department of the Navy, Bureau of Ships, Washington, D. C. K. C. Harder, B. H. Bush.

WALTON, JOHN NEWTON, Instructor of Mechanical Engineering, Villanova University, Villanova, Pa. J. S. Morehouse, R. E. White.

WEST, JOHN TUNNELL, JR., Executive Secretary, Pennsylvania Society of Professional Engineers, Harrisburg, Pa. K. W. Riddle, W. J. Stevens.

WHEELER, WARREN R., Assistant Professor of Electrical Engineering, University of Denver, Denver, Colorado. A. E. Paige, F. S. Fry.

WILLIAMS, EDWIN T., Associate Professor of Chemical Engineering, The Pennsylvania State University, University Park, Pa.

YEN, JUI LIN, Lecturer, Electrical Engineering, University of Toronto, Toronto, Canada.

55 new members
162 previously added

217 new members this year

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1956).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at Iowa State College, June 28, 1956.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.
The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant enginering practice in the next 15 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences?
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1956. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1956.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1956 to the Secretary, W. Leighton Collins, University of Illinois, Urbana, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of General and Regional Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute of Technology	April, 1956	J. W. Graham, Jr., Carnegie Institute of Technology
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Wichita	Oct. 26–27, 1956	J. K. Ludwickson, University of Nebraska
Michigan	Wayne University	May 5, 1956	G. H. Howell, Wayne University
Middle Atlantic	New York University	Dec. 3, 1955	C. C. Carr, Pratt Institute
Missouri-Arkansas	St. Louis University	April 7, 1956	J. B. Macelwane, St. Louis University
National Capital Area	Capital Radio Engineering Institute	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	University of Maine	Oct. 8, 1955	W. S. Davis, University of Maine
North Midwest	South Dakota State College	Nov. 4–5, 1955	L. L. Amidon, South Dakota State College
Ohio	Ohio State University	April 28, 1956	E. C. Clark, Ohio State University
Pacific Northwest	University of Washington	May 10, 11, 12	J. B. Morrison, University of Washington
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1955	R. G. Moses, Pasadena City College
Rocky Mountain	Denver University	April 28	W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 14–15, 1955	B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

ENGINEERS JOINT COUNCIL—GENERAL ASSEMBLY

Hotel Statler, New York City

JANUARY 26 and 27, 1956

Manpower Utilization

Thursday, January 26th, will be devoted to manpower sessions. The over-all theme of the varied presentations is Improved Utilization of Engineering Manpower. The morning sessions will provide a presentation and discussion of the meaning of Public Law 305—the Reserve Forces Act of 1955—To the utilization of engineers, scientists and other specialized personnel. The three persons bearing top governmental responsibility for these matters have graciously agreed to be present for short formal presentations followed by discussion. They are General Lewis B. Hershey, Director of the Selective Service System; Mr. Carter L. Burgess, Assistant Secretary of Defense for Manpower and Personnel, and Brigadier General Carlton S. Dargusch, Assistant Director for Manpower in the Office of Defense Mobilization. This will be perhaps the first time that this triumvirate bearing major responsibility for military and related manpower problems in government will have been available on the same platform to present an authoritative over-all picture.

The luncheon speaker will present under the title "Brainpower—Our Most Precious Asset" a current picture of the relation of our nation's brainpower potential to estimated needs. For this purpose the results of the EJC Special Surveys Committee Survey of Demand for Engineers and Engineering Technicians, a study now under way, will be presented. The implications of this and long range evaluations of our manpower need as against our potential will provide an interesting backdrop for the afternoon sessions.

"Extending Engineering Manpower by Utilizing Balanced Teams of Engineers and Engineering Technicians" is the theme of the afternoon session. This will present a specific analysis of the principal ideas and problems involved in the efficient integration of engineers and engineering technicians on the engineering team.

Dr. Eric A. Walker of Pennsylvania State University will open the session with an assessment of the "Preparation and Relative Capabilities of Engineers and Engineering Technicians." This will be followed by a presentation by Dr. L. E. Saline of the General Electric Company on the "Recruitment, Training and Placement of Technical Institute Graduates—A Centrally Controlled Program." Dr. S. W. Herald, Engineering Manager, Air Arm Division of the Westinghouse Electric Corporation will then discuss "Planning the Ideal Engineer-Engineering Technician Team in a New Engineering Department."

This will be followed by a series of short presentations on the specific records of achieving an efficient engineering technician team in various industries. These will include the Automotive Industry, the Aircraft Industry, Heavy Construction Industry, Petroleum and Chemical Industry and Government Public Works Activities.

Growth Patterns

The morning of Friday, January 27th, will be devoted to a discussion of the Growth Pattern of the Engineer. Panel moderator will be Mr. Sidney D. Kirkpatrick of the McGraw Hill Book Company. The Educator's viewpoint will be discussed by Dean Morrough P. O'Brien, chairman, Dept. of Engineering, University of California. Industrial aspects will be presented by Mr. James H. Taylor, Director of Public Relations, Procter & Gamble Company, Cincinnati, Ohio, and a discussion of the Employee's Viewpoint by Mr. Robert Nelsen, General Electric Company, Cincinnati, Ohio. Various human problems in engineering will be discussed by Mr. Earl Brunner of Rogers, Slade & Hill, New York City.

Dr. S. C. Hollister, Dean, School of Engineering, Cornell University, and a member of the Hoover Commission, will speak on the "Objectives of the Hoover Commission." The afternoon will then be devoted to a presentation of "The Engineering Aspects of the Hoover Commission Reports." Dr. Mervin Kelly, President, Bell Telephone Laboratories will discuss Research and Development Aspects of the Hoover Commission Reports, and Admiral Ben Moreell of Jones & Laughlin Steel Company will present a discussion of the Hoover Commission and its Water Resources Report.

At dinner on Friday evening, Dean Thorndike Saville, retiring President of Engineers Joint Council, will address the Council. The guest speaker, Mr. Walker L. Cisler, President of the Detroit Edison Company, will present "A World Look At Usefulness Of Nuclear Power."

(The Assembly is open to members of ASEE. For officers and organization of EJC, see page 405.)

The Journal of ENGINEERING EDUCATION

January, 1956 *Table of Contents* Vol 46, No 5

Articles

Do You Know	W. L. Collins	414
Iowa State College—Host for ASEE Annual Meeting		417
Can 500,000 Engineers Be Professional?	Eric A. Walker	421
English Program as Engineering Teachers See It	Frank Kerekes	427
Tests for Guidance and Counseling	Marvin D. Dunnette	434
MIT's Practice School	Robert C. Reid	441
Economics in Chemical Engineering	R. S. Aries and R. M. Cziner	446
Mechanics Teachers—Their Cross and Their Crown	D. H. Pletta	453
Teaching Engineering Sciences	Sheldon S. L. Chang	456
Small Company Looks at Engineering Education	John L. McLucas	458
Trends in Engineering Education	V. L. Parsegian	461
Operation Cooperation	W. L. Howland	467
Editorial Policy		469

Departments

YET-itude: You Can't Do It All At Once	Robert T. Howe	472
T-Square Page: Chairman's Message	William E. Street	475
College Notes 476	In the News	478
Teaching Positions Available 479	New Members	481

Reports

Executive Board Minutes		484
General Council Minutes		485
Industrial Fellowship Announcement	Ralph A. Morgen	496
Engineering Economy Committee Functions	Arthur Lesser, Jr.	498
ECPD—Proposal for Survey of Profession	Thorndike Saville	500
Resolution; Origins of Proposal	Warren L. McCabe	501
Toronto Address: Need for Appraisal	S. C. Hollister	503

Notes

Walker V.-P. Penn. State	416	Award to Garrelts	476
Kerekes President ACI	426	Tech. Institute Bulletins	483
ASEE Proceedings Volume	440	ASEE Summer Schools	502
Mathematics Conference	452	Russian Secondary Education	507
ECRC Research Review	457	YET Contest Rules	508
New Lowell Course	460	Membership Application	ix
Michigan Programs	471	Nomination Blank	x
Cooper Made Chairman	474	Section Meetings	xi

DO YOU KNOW . . . .

► . . . . That at its meeting in November the Executive Board and Council of the Society approved a budget of $26,100 for the study of atomic energy education as proposed by the Atomic Energy Education Committee headed by P. N. Powers of the Internuclear Company? This will be a comprehensive study, similar to that for *The Evaluation of Engineering Education.* The areas to be studied are present and future requirements for men in nuclear fields; undergraduate, graduate, and special programs for training engineers; the part of colleges and universities; the long-term role of training in Government Laboratories. Chairman of the study group is Dean G. A. Hawkins of Purdue University. The Atomic Energy Education Committee has been working very closely with the Atomic Energy Commission of the Federal Government, and since there is now some evidence that the Government Laboratories may decrease their educational programs as time goes on, the need for this study is very great. It is expected that two years will be required for completion. Funds are being sought from industries interested in engineers with training in nuclear specialties.

► . . . . That you should keep your eyes open for the final report of the Humanistic-Social Research Project? It should be received from the printer next month and copies can be obtained from this office for 25¢ each, 20¢ each in lots of 50 to 100, and 15¢ each in lots over 100. After acceptance by the General Council of ASEE, the report will be published in the JOURNAL.

The ASEE General Council will be asked to approve the report at its June 25 meeting. It is then proposed to ask approval for the spending of remaining funds to pay expenses of active committee members who are invited to speak at Section and other meetings where the findings of the report can be more fully discussed and publicized. Section officers and program chairmen—take a hint!

► . . . . That progress is being made in the Armed Services' handling of technical manpower? The material in the paragraphs below was prepared by President M. M. Boring for the President's News Letter, sent out in October, but it is important enough to repeat here as information we all should have.

"The Reserve Bill passed by the Congress and signed by the President became law in August, 1955. Included in this law is a provision for up to 250,000 young men 18½ years of age and below, and a group of young men 18½ years and beyond who have critical skills and who are in short supply to be permited to enlist in an active Reserve unit for a period of 7½ years, the initial enlistment to include six months of active duty.

"The Bill also provides for the screening from the Active Reserve to the Standby Reserve those individuals who can demonstrate that their skills in a civilian capacity override the military skills they have acquired, providing the number so classified is in excess of the military requirements for that particular skill.

"The criteria for the identification of those individuals with these critical skills and the criteria for their being screened from the Ready to the Standby Reserve are 'in the mill' in Washington.

"Many discussions have been held in connection with the development of these criteria, and it is apparent that the final outcome will be satisfactory. Our engineering students will then find themselves much better able to identify their responsibilities both in the timing and length of service period.

"As Chairman of the Engineering Manpower Commission and a member of the Committee on Specialized Personnel, I will constantly keep in touch with this pending action, and as soon as definitions are complete and established I will provide information to all of the engineering schools."

► . . . . That suggestions are available for the many of you who are now preparing programs for the Annual Meeting or are thinking about a talk or report to be presented? Everyone on the program should "speak to the audience" this year and not "read a manuscript." What is required for good oral presentation is not necessarily the same as what is required for a manuscript to be printed, nor is an acceptable manuscript a faded copy of the oral version. *Program chairmen* see that every speaker makes his dual preparation—a vigorous oral presentation to make the audience sit up and take notice, and a potent, compactly written manuscript for publication in the JOURNAL. Every Division should have good papers to submit. The English and Social-Humanistic Divisions are being asked to clarify some of the differences between oral and written work. We hope that these comments, in expanded form, will become available in the near future as articles or style sheets.

► . . . . That in developing the program for its third meeting, the Executive Committee for the EUSEC Conference on Engineering Education and Training assigned the topic "Criteria for Professional Recognition" to the United States of America? Dean Thorndike Saville of New York University is serving as chairman of the U. S. delegation and in behalf of the EUSEC Societies of the United States has had a questionnaire prepared and mailed out to all participating societies of the engineering societies of Western Europe and the United States. ("EUSEC" means European-United States Engineering Education Conferences.) The four pages of questions deal with such current problems as the definition of a professional engineer, legal requirements for professional practice of engineering by an individual, legal requirements for professional practice of engineering by a corporation, criteria for professional recognition other than legal, and titles of recognition. Attached to the questionnaire is the following definition of "Professional Engineer."

"A professional engineer is competent by virtue of his fundamental education and training to apply the scientific method and outlook to the solution of problems, and to assume personal responsibility for the development and application of engineering science and techniques especially in research, designing, manufacturing, superintending and managing. His work is predominantly intellectual and varied, and not of a routine mental or physical character, but requires the exercise of original thought and, if necessary, the responsibility for supervising the technical and administrative work of others.

"His education will have been such as to make him capable of closely and continuously following all progress in his

branch of engineering science by consulting newly published work on a world-wide basis, assimilating this information and applying it independently. He must be able to make contributions to the development of engineering science and its application.

"By virtue of his education and training he will have acquired a broad and general appreciation of the engineering sciences as well as a thorough insight into the special features of his own branch, with the result that in due time he can give authoritative technical advice, or be responsible for the direction of important tasks in his branch."

► . . . . That you should be sure to read the Statement of Policy this month, in which the Editor presents a few ideas about the JOURNAL and JOURNAL articles!

W. LEIGHTON COLLINS
Secretary

WALKER NAMED VICE-PRESIDENT OF PENNSYLVANIA STATE UNIVERSITY

Dr. Eric A. Walker, Dean of the College of Engineering and Architecture at the Pennsylvania State University, has been named vice-president of the University, effective June 30, 1956. In announcing the appointment, President Milton S. Eisenhower explained that Dean Walker will coordinate and stimulate the research program. Appointed Dean of the College of Engineering and Architecture in 1951 to succeed the late Dean Harry P. Hammond, Dr. Walker came to Penn State in 1945.

From 1942 to 1945, Dean Walker rose from research associate to associate director of the Harvard Underwater Sound Laboratory at Cambridge, Massachusetts. For his work there, he was awarded the Naval Ordnance Development Award and also a Presidential Certificate of Merit. From 1945 to 1951, the vice-president designate served in a dual role as director of the Ordnance Research Laboratory and as professor and head of the Department of Electrical Engineering.

As Dean of the College of Engineering and Architecture, Dr. Walker has greatly expanded the work of the College to include the construction of the Research Reactor, the computation center in the department of electrical engineering, and the development of the program in engineering science.

Born in Long Eaton, England, Dr. Walker received his bachelor, master, and doctor of science degrees at Harvard University. He has served as a vice-president of the American Society for Engineering Education and as a director of the Engineering College Research Council. He is a member of the American Institute of Electrical Engineers, the American Physical Society, a fellow of the Acoustical Society of America, a member of Tau Beta Pi, engineering honor society, and is a registered professional engineer in Pennsylvania and Connecticut.

IOWA STATE COLLEGE HOST FOR ASEE ANNUAL MEETING

The sixty-fourth annual meeting of ASEE, June 25–29, 1956, will enjoy the hospitality of the Engineering Division, Iowa State College, at Ames, Iowa. A pleasant town with a population of 15,000 (excluding students), Ames is located near the center of the state, some 35 miles north of the capital city of Des Moines, and is easily reached by auto, rail, or plane. East-west transcontinental highway U. S. 30 and north-south U. S. highway 69 join there. The main line of the Chicago and Northwestern Railroad passes through Ames, and transcontinental planes stop at Des Moines, an easy bus trip away.

An active group of local committees, headed by Professor L. O. Stewart and G. R. Henninger, have been planning arrangements, and promise a warm welcome with accommodations equal to any. Ample housing will be available on campus as well as in Ames, and an extensive schedule of entertainment is being projected.

Background

Iowa State, now enrolling more than 9000 students, was one of the first of the land-grant colleges. Its establishment was begun late in 1862, though the first students were not admitted until 1868. The first curricula were, of course, agriculture and "mechanic arts," the latter soon broadening into engineering. Until 1870, the essentials of mechanical and civil engineering "arts" were taught, plus courses in social science, philosophy, and the cultural studies allowed by the land-grant act.

By 1873 a specific curriculum in mechanical engineering had been established; civil engineering became a separate department in 1876, and both mining engineering and architecture were listed as separate studies in the catalogue of 1877. The Bachelor of Science degree was awarded in Engineering until 1878, when the Bachelor of Civil Engineering and Bachelor of Mechanical Engineering were conferred, with advanced degrees of Civil Engineer and Mechanical Engineer. (Through 1955, a total of more than 12,000 degrees in engineering had been granted to graduates who have served the profession with distinction in all parts of the world.)

The Division of Engineering was organized as such about 1896, with four departments. The largest of five major divisions in the College as a whole (the others being Agriculture, Home Economics, Science, and Veterinary Medicine), Engineering now enrolls more than 3000 students in eleven departments and curricula. These include aeronautical engineering, ceramic engineering, chemical engineering, agricultural engineering, architecture and architectural engineering, civil engineering, electrical engineering, industrial engineering, and mechanical engineering. Graduate courses, given in each of the curricula named and in nuclear engineering and theoretical and applied mechanics, lead to advanced degrees.

These several departments are supplemented by an Engineering Experiment Station, among the earliest organized in the nation, an Engineering Extension Service, and the Ames

Laboratory of the Institute for Atomic Research.

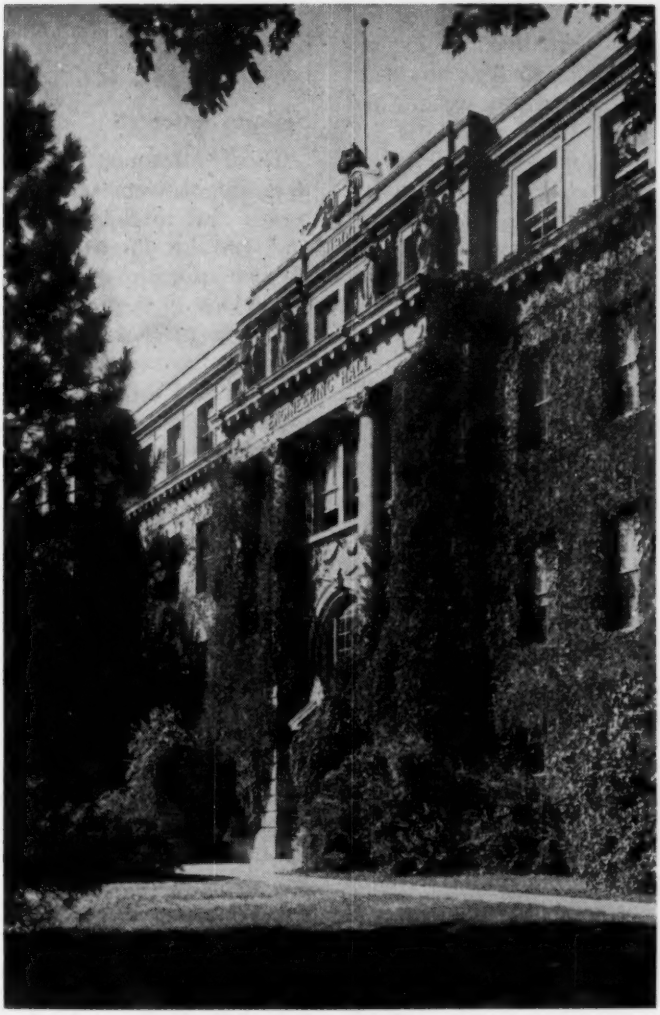
Iowa State College is continuing to expand under its tenth President, Dr. James H. Hilton, as is the Division under its third Dean, J. F. Downie Smith. (Dean Anson Marston was first in succession for Engineering, from 1904 to 1932, with Thomas R. Agg as the second from 1932 until 1947, when Dean Smith was appointed.)

On the spacious and beautiful campus created from what was originally open prairie, with a site located only by survey lines, the Division of Engineering now occupies more than ten major structures. Headquarters are in Marston Hall, the main engineering building. Other activities are housed in the Engineering Annex, the Electrical Engineering Building, and in separate structures for Agricultural Engineering, Mechanical, Aeronautical, two buildings for Chemical Engineering, and an Experiment Station. These are supplemented by a group of auxiliaries serving all the departments and the Experiment Station.

Activities of Interest

In addition to the instructional laboratories, all of which will be on display for the ASEE, several extensive facilities will demand inspection. Ames is a center of nuclear science, an important aspect of the 1956 ASEE program. The Ames Laboratory of the United States Atomic Energy Commission played an important part during World War II. Facilities of the Institute for Atomic Research and the Ames Laboratory include buildings for offices, general

Electrical Engineering Building, Iowa State College, Ames, Iowa



Marston Hall, Headquarters for Division of Engineering, Iowa State College

work areas, for research, metallurgy, and the Synchrotron—all built since World War II. (A related feature of the Annual Meeting will be the banquet address by U. S. Senator Bourke B. Hickenlooper, of the Joint Congressional Committee on Atomic Energy.)

A second outstanding point of interest will be the Engineering Experiment Station. Active work is being carried out on more than thirty extensive research projects, as well as many minor investigations. Activities are included for all the primary engineering fields. Examples of larger projects are those on the utilization of agricultural by-products, manufacture of fertilizers, extraction of vegetable oils, development of highway

materials and construction methods, soil mechanics, creativeness in machine design, and analysis of problems in electrical transmission and distribution.

The publication of research results has always been an important activity of the Station. More than 175 bulletins have been issued, and numerous papers have been prepared for presentation to engineering societies.

WOI-TV

A visit to the studios of WOI-TV, the first educational television station to be opened for operation, and the 100th station to begin telecasting in the United States, is a must for all ASEE visitors concerned with the audio-visual arts. WOI-TV is also unusual in being an educational station which carries commercial programs for profit. It utilizes Channel 5, with a power of 500,000 watts, from a transmitter tower 580 feet high, to cover an audience radius of 100 miles for more than sixteen hours per day.

Established in February, 1950, WOI-TV is a modern extension of the traditional land-grant college concept of service to the public. Its operations emphasize teaching, program development, and student experience both in production and in engineering capacities.

Highway Research

Third attraction is the extensive program of work with highway materials and methods of construction, and the headquarters of the State Highway Commission in Ames, about a mile east of the Iowa State Campus. Although there is no direct organizational connection between the Commission and the College, the Experiment Station carries on broad research under the sponsorship of the Commission.

In short, as the map will show, all roads lead to Ames for Engineering Educators in 1956. There will be a rich program, old friends, and much of technical and agricultural interest to see. Also, for those vacation-bound after the meeting, Ames is an excellent jumping-off point in any direction. Easterners will find Iowa well on their way to the West, or to the north woods and lakes; for the West, Ames opens both the South and East. Be sure to put June 25–29 on your calendar, and enjoy true mid-western hospitality!

Iowa State College Committee for the Annual Meeting

General Chairman ...L. O. STEWART Vice Chairman ....G. R. HENNINGER

Committee Chairmen

Auxiliary Services ...L. R. HILLYARD
Banquets and Luncheons E. W. ANDERSON
Conferences and Sessions G. R. TOWN
Displays and Exhibits ...J. S. RISING
Finance .....MORTON SMUTZ
Housing and Registration M. E. GOULD
Ladies Program ..MRS. H. M. BLACK
Printing .....H. J. STOEVER
Publicity and Information J. H. BOLTON
Transportation .....L. H. CSANYI
Trips and Entertainment L. S. LINDEROTH
Young Peoples Program MRS. J. F. SANDFORT

CAN 500,000 ENGINEERS BE PROFESSIONAL?

ERIC A. WALKER

Dean, College of Engineering and Architecture
Vice-President-Elect, The Pennsylvania State University
University Park, Pennsylvania

In the early 1930's, Matthew Woll, vice-president of the American Federation of Labor, is supposed to have told a group of engineers, "The trouble with you fellows is that you fancy yourselves as professional men; actually, you are just hired help." The statement is true, whether it was actually made or not. Engineers do like to believe they are members of a *bona-fide* profession, yet most of them are salaried employees. The real question is not the truth of the statement, but the truth of the assumptions on which it is based. Does the fact that engineers are "hired help" bar them from the ranks of professional men? Are unionization and professionalism incompatible? And how sound is the engineers' claim to professional status?

For all practical purposes, the engineers' interest in professionalism has been linked with the question of unionization for just about twenty years. When the Labor Relations Act was passed in 1935, many engineers were included in bargaining units along with technicians, factory workers, artisans, and other "subprofessionals." This grouping was perhaps a natural one. Engineers have by tradition worked closely with these groups, and it is these groups that have worked hardest for unionization. By focusing attention on the engineer's ambiguous position, however, the new law aroused his interest in professionalism and raised a question that has not yet been satisfactorily answered.

Grasping for straws, the officials finally ruled in this case that engineers, as salaried employees, were not eligible for union representation, which was, or should be, restricted to hourly wage workers. This ruling did not help much, and in 1944 the National Labor Relations Board attempted a more careful job of definition. "Professional engineers," NLRB declared, "do essentially creative work." The definition went on to point out that engineers write the directions for others to carry out, much as the doctor writes the prescription that is compounded by the pharmacist and administered by the nurse or patient. This fact, NLRB declared, eliminated the engineers from nonprofessional ranks.

Once the question had been raised, however, it was not to be settled easily. Consequently, the Taft-Hartley Act attempted to spell out the requirements for professionalism in terms of both the man and his work. "The term professional employee," it ruled, "means

A. Any employee engaged in work (1) predominantly intellectual and varied in character, as opposed to routine mental, manual, mechanical, or physical work; (2) involving consistent exercise

of discretion and judgment in its performance;

(3) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time;

(4) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes; or

B. Any employee who

(1) has accomplished the course of specialized intellectual instruction and study described in clause 4 of paragraph A; and

(2) is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph A."

Perhaps these rulings and interpretations formed an adequate basis for administering the law. They failed, however, to satisfy the engineer. Perhaps they kept the door to professionalism from being slammed in his face; but they failed to convince him —or the public—that he is, in fact, a member of a profession. Engineers have been trained too long and too well to forge their opinions in the crucible of stubborn and irreducible facts to draw a conclusion so easily, even a desirable one.

What, actually, is the professional status of the engineer? Is he already under the sun but fails to realize it because his eyes have not yet adjusted to the new light? Or is he still groping to find the door left open by the legal interpretations?

"Professionalism" is not an easy word to define. The learned professions, according to Noah Webster, are the law, the ministry, and the healing arts. However, not all doctors, for instance, qualify, just as not all officers of the Armed Forces qualify as gentlemen, despite the Act of Congress conferring the title on them. On the other hand, public acceptance often confers professional status on individual members of groups outside the traditional three. Almost every community, for example, has a landscape artist who is a "real professional."

Actually, as these examples show, professionalism is a double-barreled sort of thing. In part, it is *obtained* by satisfying certain established conditions, such as those spelled out in broad outline by the provisions of the Taft-Hartley Act. But in part it is *conferred* by the community at large on an individual or group because of the acceptance by that individual or group of a code of ethics—a code that the individual or group refuses to compromise for personal gain or prestige. None of the legal interpretations mentions this aspect of professionalism.

Thus, the officer is a gentleman (1) because he has satisfactorily completed all the rigorous requirements for a commission in one of the branches of the Military and (2) because his personal conduct is recognized as being exemplary. The officer who fails to qualify on the second ground is the true author of the derisive phrase "officer and gentleman—

by Act of Congress." The medical doctor, by virtue of his title alone, is a professional man on the first ground; the landscape artist qualifies only on the second.

What are the tangible requirements for professionalism? And how do the engineers stack up as a group with the traditional professions in these requirements?

Let's use the medical doctor for comparison. Before he is allowed to offer his services to the public, he must have received a degree from a university, taken three to five years of postgraduate work, served an apprenticeship, and passed a rigorous examination. That's all there is to it, except for the fact that the curriculum, apprenticeship, and examination are so tough that he must have higher-than-average intelligence, ability, and perseverance to arrive finally at his own practice.

Here the engineers stack up rather well. Undeniably, it requires an intelligence higher than average to complete today's engineering curricula. At The Pennsylvania State University, for instance, only one out of every three freshmen who enter the College of Engineering and Architecture lasts long enough to be finally handed his parchment replica of the traditional sheepskin. In addition, studies have shown that the undergraduate with an I. Q. of less than 120 has little chance of securing his B.S. degree in engineering.

It can also be shown that an engineering career demands long hours of postgraduate work at a university, in company courses, or through self-study. Many industries today offer training courses and curricula equivalent in every respect to those offered at the graduate level in academic institutions.

It is true that comparative training for engineering is not quite as long as that required for either the lawyer or the medical doctor, each of whom must obtain a bachelor's degree before attending his specialized school. The engineers, however, have followed the doctors and lawyers in establishing public licensing laws. In most states, this license is granted only after the completion of an apprenticeship under the direction of a licensed engineer. This takes care of the M.D.'s internship. In all states, the engineer must pass a rigid examination before the title "professional engineer" is granted him.

This title indicates the engineer has essentially met all the tangible requirements for professionalism. How does he measure up by the intangible standards?

It is difficult to analyze what causes a person or group to be accepted as being professional by the public. It is clear, however, that this acceptance is not based on objective or legal standards. The title does not *per se* confer professional status. It indicates a professional *competence;* it does not yet indicate a professional *morality.*

Let's look again at the doctor. Traditionally, doctors selflessly devote their lives to the public welfare. The popular belief is that, as a group, they are dedicated to the service of humanity, just as are ministers. All studies show that doctors have the highest annual income of all classes of "workers." The public seldom thinks of this; it thinks, rather, of the early morning calls to take care of Johnny's stomach ache, made despite the fact that Johnny's father is out of

work and cannot pay for the call. The demand for doctors today is tremendous, and any graduate M.D. is guaranteed a lucrative practice. When Johnny decides to enter medical school, people speak admiringly of his sacrifice and dedication, of the long years he must spend in training, not of his prospective income.

All this adds up to an attitude: an attitude, or a set of attitudes, defining the moral responsibilities of the man to his job and the outlook of the public toward the man as a member of a group. As an attitude, it cannot be legislated, any more than prejudice can be eliminated by Federal decree or the attitude of the people toward drinking could be changed by a Constitutional amendment. It cannot be conferred or denied because of the grade on an examination. It has nothing to do with the amount of training required to do the job. It takes no account whatever of whether the man is a hired hand or an independent practitioner, or whether he works in his private quarters or in a big office with hundreds of others.

Francis Bacon wrote, "I hold every man a debtor to his profession." A more modern writer put it this way. "Professional status is granted by the public through recognition, identification, and respect for learning and service of the individuals in the professional category."

In other words, the professional man is one whose reputation for competence and integrity is such that uninformed laymen can, and do, entrust their lives, their health, and their property to him. To win this reputation, he must first of all approach his calling as a position of public trust. It is a question of the assumption of public responsibility.

The doctors do not leave the inculcation of this attitude, or code of behavior, to chance. Even during his premedical training, the embryonic M.D. begins to receive instruction about his responsibilities and duties to his fellow men. This training culminates in the administration of the Hippocratic Oath, with its emphasis on self-sacrifice, upon his graduation from medical school. Machinery is even set up to enforce its observance by punishing those who, through weakness or selfishness, fail to adhere to it.

It is this standard of behavior, this code of ethics, that makes it difficult to rationalize professionalism and unionization. Unionization concentrates on the relationship between the employee and his boss. Professionalism centers on the relationship between the man and his work.

The major purpose of a union is to improve the lot of the employee by securing for him increased wages, improved working conditions, and the fringe benefits he desires. This is an essentially selfish goal. It puts "my" good first, above the good of my fellow men, if need be. It results, for instance, in higher wages for coal miners, even though the method of obtaining this increase cuts off the nation's coal supply in the middle of December.

The professional man's task calls for discretion and judgment and requires him to produce the best possible answer in any particular situation. The best possible answer for whom? First, for humanity; second, for his employer; third, if there is a third, for himself.

There is little pressure for the average factory worker to worry about humanity. His daily activity, except

in isolated instances of mercy and the like, little affects the public welfare. On the other hand, it is absolutely necessary for the doctor to be concerned with humanity at large, since almost every decision he makes involves the general well-being of the community.

But isn't this true also of the engineer? He designs our roads and the automobiles that travel on them. He designs the buildings, the factories, sometimes the cities in which we work and play. He designs the equipment that frees man from undignified and life-shortening labor, from the simple vacuum cleaner to the giant computers that perform in seconds calculations that would require scores of mathematicians years to complete. He designs the weapons that permit us to maintain our ability to protect our way of life effectively and to prevent the enemy from devastating our land with an annihilative war. No one, not even the doctor, is more responsible for the health and welfare of our country than is the engineer.

To be accepted as truly professional, then, the engineer must meet this challenge. He must make it clear that he recognizes his duty to humanity and is prepared to accept it. It must be obvious that his decisions are aimed first at the good of the community. His own selfish interests must be clearly subordinated. "Where there is love of man," Hippocrates wrote, "there is love of art."

It is here that the engineer is at the crossroads. One branch leads to professionalism, the other to craftsmanship. Not all engineers, however, are convinced that the road to professionalism is the right one to take. Of the half million engineers with some claim to professionalism, almost 40,000 are presumably sufficiently dissatisfied with their present status to join engineering unions in the hope of improving their lot.

There are ever-increasing signs, however, that more and more engineers are recognizing their corporate duty to mankind and are prepared to accept the discipline it demands. For instance, the American Society for Engineering Education, which pioneered the inclusion of socio-humanistic studies in the engineering curricula, established in 1952 a committee to study the problem of ethics in engineering. Interest in the work of this committee has been so high that the committee has had little time to do anything but answer its correspondence. Although the engineers have nothing sufficiently traditional to compare with the Hippocratic Oath, a limited survey by the ASEE committee revealed that 70 per cent of the 87 colleges of engineering polled gave some sort of instruction in ethics to the engineering undergraduates. In another instance, the more than 33,000 members of the National Society of Professional Engineers voluntarily accepted in 1954 a creed that reads, in part,

> "As a professional engineer, I dedicate my professional knowledge and skill to the advancement and betterment of human welfare. I pledge . . . to place service before profit, the honor and standing of the profession before advantage, and the public welfare above all other considerations."

In actual performance, the engineers have demonstrated this awakened consciousness of public duty. Seldom do you hear of an engineer performing a technological abortion, as those who make decisions based

upon recommendations of engineers often seem to do. Even the severest critics admit that when the chips are down (as they were in World War II) the "engineering achievement was indeed phenomenal." "The 'guild of engineers,'" one critic grudgingly admitted, "eagerly knuckled down to meet the quotas. . . ." Engineering decisions are not always popular, but they are remarkably honest. Surely this is the beginning of a professional morality.

If the engineers accept this tremendous discipline for selfless service to the public welfare—if they accept the responsibility of directing their rather frightening potential for harnessing the forces of nature for the good of mankind—the public will not long delay the conferring of professional status. And all signs indicate that most engineers, both as individuals and as members of a group, have already stepped out firmly in the direction of professionalism.

KEREKES TO BE PRESIDENT OF AMERICAN CONCRETE INSTITUTE

Frank Kerekes, Dean of the Faculty, Michigan College of Mining and Technology, Houghton, and member of ASEE since 1927, has been nominated as President of the American Concrete Institute to succeed Charles S. Whitney for a one-year term beginning at the February, 1956, convention.

Dean Kerekes has been a member of ACI since 1938. He is chairman of Committee 318, Standard Building Code, and a member of Committee 315, Detailing Reinforced Concrete Structures. He has been serving as vice-president since 1954 and has served on the Technical Activities Committee, 1948–50, and the Board of Direction, 1951–54.

Dean Kerekes received his BS degree from City College of New York and the degree of Civil Engineer from Columbia University. He immediately joined the civil engineering faculty at Iowa State College, Ames, where he served for 34 years and advanced to be assistant dean of engineering. While at Iowa State he also served as chairman of both the Ames City Plan Commission and the Iowa Building Code Council. Kerekes is Past President and Honorary Member of the Iowa Engineering Society, which presented him with the Anson Marston and John Dunlap Medals. He is a member of the Michigan Engineering Society.

He is the author of text books and articles on education and civil engineering and has served as consulting structural engineer for architectural firms and industrial organizations. He is active in professional and civic circles.

THE ENGLISH PROGRAM AS ENGINEERING TEACHERS VIEW IT

FRANK KEREKES

Dean of the Faculty
The Michigan College of Mining and Technology
Member, General Council, ASEE

Presented at the English Division Conference, the ASEE Annual Meeting, Pennsylvania State University June 21, 1955

A civil engineer practicing in structural analysis and design, Dean Kerekes had his first opportunity to learn English after he was seven years old. He has for more than thirty years been closely associated with the teaching of a required course in report preparation, and for more than ten years was chairman of a College-wide Committee on Student English. These experiences are the setting for his "intense conviction that power in the use of English is the essential skill in all professions."

We are at the point where many are urging a critical and comprehensive review of the content, function, and method of teaching English in the freshman year of engineering curricula. Furthermore, there has been so much of value written and said about the apparent shortcomings of prevailing English programs that implementation and action rather than continued surveys and deliberations are the urgent need.

The teachers of English and of the other subjects in the college curricula should combine and cooperate in their program for developing effective means of communication among college and university students. To accomplish this objective each should be conscious of and sympathetic with the problems of the other. An eminent mining engineer, a generous public servant, Past President of the United States of America, and a venerable citizen of the world, Herbert Hoover, epitomizes the engineering profession thus:

"I cannot leave my profession without some general comment upon it. Within my life time it has been transformed from a TRADE into a PROFESSION. It was the American universities that took engineering away from rule-of-thumb surveyors, mechanics and Cornish foremen and lifted it into the realm of wider learning in the humanities with the higher ethics of a profession ranking with law, medicine, and the clergy. And our American profession has brought a transformation in another direction through the inclusion of administrative work as a part of the engineer's job. "

With the prestige of a profession, the engineer assumes added responsibilities, not the least of which is to communicate his ideas to his fellow engineers and to the citizens of his community, be they in his home town, his state, his country or the world at large. Charles Kettering of General Motors has said that "a man's language is an index of his mind." The mind of the truly professional engineer is trained in several rigorous disciplines of expression: linguistic,

graphical, mathematical, and, to a limited extent, aesthetic. As Harry S. Rogers, Past President of ASEE, puts it:

"Because of competitive demands for time in such training, writing upon engineering matters has frequently failed to receive the attention necessary to develop any degree of proficiency, and courses in composition have lacked the motivation which could have been made available by compilation of stirring, challenging, and interesting informative writing."

Fortunately this is an opportune time not only to evaluate existing English programs but also to develop new ones. There is a growing recognition among scientists, engineers and educators that the faculties of departments of English have important new contributions to make. By the very nature of their training, experience, and interest they can serve the broad function of developing among freshman engineering students the humanistic-social consciousness. They can perform this function and at the same time strengthen their influence in the application of the principles which govern the use of language in writing, speaking, reading, and understanding. The ASEE Committee on the Evaluation of Engineering Education made its final report in June, 1955. As a result of the findings of this report many schools of engineering will be giving serious attention to curricula revisions. Certainly, no more effective time could present itself for the introduction of a new, vital, and vigorous English program.

What Do We Have to Offer?

Broadly reviewed, the contents, objectives, and emphases of freshman English courses available to engineering students are in too many instances patterned after programs which could logically celebrate their fiftieth if not their one-hundredth anniversaries. Formal engineering education in the United States of America is hardly more than 125 years old. In that time there has been a tremendous extension in the science and practice of engineering, not to mention the transition from a largely empirical approach to a highly abstract, mathematical, technological and industrial treatment. Yet, with a few noteworthy exceptions, English programs for engineers are gripped by precedent rather than liberated by the challenge of evident, realistic, and creative possibilities for improvement.

What do we have to offer today? Let us go to the college catalogues to provide the answer, which could be summarized as follows:

English A–B–C. Three credits per term throughout the freshman year.

"Frequent short papers. The fundamentals of expository writing; outlining, paragraphing, sentence structure, mechanics. Study of formal grammar. Study of expository prose. An approach to judicious reading. Careful analysis of both good and bad writing. Materials for writing to be drawn from readings in imaginative literature."

In contrast to the foregoing (which is the usual pattern), there are all too few indications of an effort to make English more vital, stimulating, and challenging.

English X–Y–Z. Three credits per term throughout the freshman year.

"This course is designed to help students think, speak, write, and understand the living English of the United States of America.

"Emphasis is placed upon skill in using clear, forceful, accurate, and idiomatic language for expression of ideas, and

upon skill in intelligent, critical, and discriminative reception of ideas.

"The skills involved in reading, writing, speaking and listening are combined in a single course (throughout the year), because intelligent use of language is equally essential to all of them.

"As clarification of meaning is a prerequisite of all learning, the ability to clarify and to communicate ideas efficiently and effectively is the aim of this course."

The first catalog description, English A–B–C, typical of the English program offered to most freshman year engineering students and presumably to all freshman students in most colleges, appears to be based upon the premise that high school English does not "TAKE," so the college department of English must use the energy, time, and effort of mature and able English teachers to inculcate English disciplines which should have been acquired in high school. Furthermore, in most institutions, little if any attempt is made to differentiate between the well prepared and poorly prepared high school graduate insofar as the credit they receive for high school English or the challenges presented in their college English requirements are concerned.

The second catalogue description, English X–Y–Z, is the exceptional English Program available to Freshman Year engineering students. One must admit, however, that, not having the course outlines at hand, one cannot know how much difference there may be in the actual course content and method of teaching between typical courses English A–B–C, and unusual courses English X–Y–Z.

Does Freshman English "TAKE"?

Judging from the continuous and persistent assertions made by teachers and employers of engineering students, one may conclude that the answer to this question, unfortunately, is practically a unanimous NO! This unpleasant evaluation should not be charged indiscriminately to failure by all students of engineering or to the ineffectiveness of able and sincere teachers of English. The writer believes that this negative appraisal can be directly attributed to the very nature of prevailing English programs and to the lack of well planned follow-up writing requirements and standards demanded by the teachers of engineering subjects.

Let us get down to specific results obtained in a survey of the writing performance of Junior and Senior students. Papers were gathered from at least one entire section of Juniors and Seniors in each of the five major divisions of the college. Students were not informed that the English was to be used for the special study. These papers were written outside of class as regular assignments. The 149 papers were then read and classified as Good, Fair, Poor, and Not Passed. Nearly every objectionable error was noted, analyzed, and classified. The approximate length of papers varied from 130 to 1000 words.

Of the 149 papers reviewed, 48 or 32% were Good, 60 or 40% were Fair, 27 or 18% were Poor, and 14 or 10% were "Not Passed." Thus one may surmise that of every ten upperclass students 3 write *Good* papers, 4 write *Fair* papers, 2 write *Poor* papers, and one writes a *Not Passed* paper. It was further observed that the results were poorer as the papers grew longer. Indications are that a student does not positively demonstrate his strength or weakness in less than from 300 to 500 words.

When only 3 out of every 10 juniors

and seniors—probably the same number holds for graduates—write *Good* papers, it is little wonder that teachers of upperclass students and employers of college graduates complain about the level of engineers' performance in English.

The analysis and classification of the errors yield results which are of far greater significance and value than the appraisal of overall quality of the written papers. The following summary omits spelling errors. Although spelling errors were recorded, the results demonstrated that many misspelled words were due to carelessness and that in an appreciable number of instances the students were able to correct their errors without the use of a dictionary.

A. Coherence, Clearness, Smoothness	48.5%
B. Grammar	22.6%
C. Diction	15.1%
D. Punctuation	13.8%

Thus one might conclude that about half of the difficulty in writing consists of inability to communicate ideas and thoughts clearly. Only about one-quarter of the errors are chargeable to grammatical errors and a similar ratio to diction and punctuation combined. The graders of these papers did not aim at perfection but merely at determining the average literacy and intelligence of work generally accepted.

The commonest errors are easy to detect. Eight easily detected errors out of thirty-one types are responsible for more than half of the mistakes commonly made. Only two are errors in formal grammar. All eight are such as to make the students' written and spoken work incorrect, clumsy, and obscure.

The teacher of sophomores, juniors, and seniors could be of invaluable service to his students if he would constantly urge them to avoid the following Eight Commonest Language Errors:

Clearness
1. General vagueness, awkwardness, inexactness.
2. Faulty reference of pronouns.

Grammar
3. Disagreement of subject and verb.
4. Disagreement of pronoun and antecedent.

Diction
5. Wrong word.
6. Faulty idiom.

Punctuation
7. Fragmentary statement written as a sentence.
8. Confusing lack of internal punctuation.

These observations are for one institution. The engineering faculty could profitably join with the department of English in any school to make a survey of how freshman English "Takes." Should such a survey be made, it is important that the paper should be written as a *regular* requirement in junior or senior courses, that the papers should be at least from 300 to 500 words in length, and that the students should not know that the papers will be scrutinized for English as well as for technical content. This type of check-up is good for the student, for teachers of technical subjects, and for the teachers of English.

How Well Do Young Engineering Graduates Write?

On the basis of general comments by their employers and by the graduates themselves, and of results obtained by actual surveys in industry, there appears to be a greater inability to meet the demands of industry for

effective writing and speaking than for effective engineering and scientific work.

In a survey of several thousand practicing engineering graduates, good English was considered to be indispensable or of considerable value by 60 per cent. Of this number about 25 per cent recommended the inclusion of more English courses in the Engineering curricula, and another 25 per cent were actually continuing to study English after graduation.

One large employer of engineering graduates made a comprehensive and careful survey of "The Young Engineer and His English." It was found that from the point of view of young graduates, the preparation of letters, memoranda, reports and other written material consumes about 25 per cent of their time. Contacts with supervisors, other employees, and the public consume another 20 per cent of their time. Nearly 40 per cent of the men found their written assignments more difficult than scientific and technical phases of their work. About 30 per cent found it difficult to express their ideas orally, either in individual conferences or with groups.

In this same survey, more emphasis on English was favored by 90 per cent of the men; more emphasis on speaking was requested by over 90 per cent; and more literature was favored by only 25 per cent.

An analysis of the survey from the viewpoint of the supervisors reveals that in the writing of letters, memoranda, and reports about 75 per cent of the young graduates use correct English, 64 per cent use clear English, but only 30 per cent use convincing English. The percentages of those who speak correctly, clearly, and convincingly are lower for speech than for writing. The specific defects occurring most often are in the order of their frequency: poor sentence structure, limited vocabulary, and poor organization of material.

It should be realized that these comments apply to young engineering graduates selected from many engineering schools representing a large variety of institutions and a wide geographic distribution. Therefore, it seems reasonable to conclude that in many schools definite steps should be taken for an improved English program.

Why Not Develop a Realistic English Program?

To stimulate creative thinking leading to the early implementation of effective English programs in those colleges and universities which will have the courage to initiate them, four recommendations are presented.

1. Stop teaching high school courses in English as freshman English in college.

2. Develop completely new motivations, objectives, contents, presentations, and functions for the courses as well as for the teacher in the proposed revitalized English program.

3. Introduce a policy, system, and method for the review by competent faculty members of at least one paper written each term of the sophomore, junior, and senior years. These papers should be written as a regular requirement of the courses in engineering subjects.

4. Insure that a full course in "Report Preparation" completes the senior year of each engineering curriculum.

To develop each of these four points a bit more completely:

1. *Emphasis on Reading, Writing, Understanding, Thinking, Learning, and Speaking:*

A review of the statements for freshmen English in college catalogues and a study of the course outlines reveal that in most cases the objectives, contents, and teaching methods are identical in nature with those of high school English programs except that the rigor may be more exacting, the teachers more experienced, and the subject matter extended. It is about time to place more faith in the seriousness and adequacy of the English programs in high schools. Then more responsibility could be placed upon the freshman student to apply accurately and effectively what he learned in high school English. Specifically, the proposal offered here is that instead of devoting time to the re-teaching of grammar, composition, and rhetoric, the student should be expected to apply what he has learned in high school to the writing, reading and understanding requirements of the course in college English. Then, the emphasis could be placed on reading, writing, understanding, thinking, learning, and speaking. In other words, both the student and the teacher of English would be working on a stimulating and mature level of mental discipline instead of devoting precious hours to the re-drilling of rules and regulations which have been or should have been acquired in high school. Grammar, composition, and rhetoric would of course be important elements in the student's performance. But the student would be impressed with the idea that these skills are expected of him. This approach should convince the student that what he has once studied and learned he is expected to apply effectively by his own volition.

Those students whose work in English throughout the freshman year is consistently substandard insofar as grammar, composition and rhetoric are concerned should be obliged to take and pass a "Practice Course" during the following year without credit toward graduation.

To make this plan effective, should the student need to take the "Practice Course," his final grade in English should be withheld until such time as he meets the standards of the "Practice Course."

2. *The Revitalized English Program:*

The entire freshman year in English should be revitalized as an orientation course in an introduction to the Humanities broadly and practically interpreted. The student can in this course become aware of engineering in its relationship to society; he can develop an interest in people and stimulate an intense civic consciousness. His reading sources can be among the many fine general and technical books, magazines, pamphlets, and newspapers of the day—of the period and time in which HE lives. Then as he matures, and after he has developed the urge to read materials of recent publication, he will develop the urge to read what great men of all time have thought and expressed in their writings.

One specific suggestion is to have the student select a topic of particular interest to him during the first week of the term. Then, let him develop this topic for the remainder of the term by reading, writing, and discussion about his chosen subject.

3. *Writing Requirements Beyond the Freshman Year:*

During each term of the sophomore, junior, and senior years in every

engineering curriculum, the department should designate some course in which occasional papers of consequence will be written as a regular requirement. Then, some designated personnel of the department of English would select at random a particular unannounced written assignment for scrutiny as to its merit. Those students who persistently present substandard written material may be expected to enroll in a drill course such as described in foregoing Item 1.

This program is important because it gives the student four years of continuous experience in writing and the benefit of departmental as well as English counsel. Then, when his employer assigns some writing responsibilities to him, he will not have to tackle his assignment after three lean years of little writing and less organized formal discussion.

4. *Report Preparation:*

In recent years it is becoming increasingly recognized that the synthesis of ideas and knowledge is of greater importance and value than the idea or knowledge itself. As the young engineer matures and as he is entrusted with increasingly broader and more intense responsibilities, he finds that he is called upon to write more letters, more memoranda, more articles, and more reports. As a matter of fact, in his early days as an engineer he is quite likely to be called upon to write a report to his superiors. On the merit of the technical content and literary effectiveness of this report will depend his recognition and advancement.

The inclusion of a "Report Preparation" course in the senior year of all engineering curricula provides the student with the opportunity to study intensively a problem of his own choice. Reports of this kind give the student experience in gathering and sifting information, in presentation, analysis and interpretation, and in the important skills of reasoning and judgment. The preparation of a report calls upon the engineering student to synthesize his knowledge through the medium of graphical, mathematical and linguistic expression, including the subtle application of aesthetic principles to produce a pleasing and desired effect.

Are We Ready to Accept the Challenge?

This brief analysis of the problem of necessity touches only the high spots. The writer has tried to stimulate each person to provide his own answers to the questions:

Where are we?

What do we have to offer?

Does freshman English "Take"?

How well do young engineering graduates write?

Why not develop a realistic English program?

Are we ready to accept the challenge?

The answer to the last question will determine for each of us whether we will return to our homes and relapse into the same routines of working and thinking, or whether we will realistically tackle one of the very important problems confronting engineering education. In every case the particular methods for implementing these major policies and objectives will need to be developed cooperatively by the faculties of English, science and engineering. If we choose to accept this challenge, then there will be a great deal of creative thinking and work to do and many people to convert and convince.

TESTS FOR GUIDANCE AND COUNSELING

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Engineers are amazingly versatile creatures. Present demands for technically trained people reflect this fact; engineers and scientists are being placed in positions ranging all the way from top-notch management administration to routine analysis and testing. Thus it is that engineers are not employed solely in purely technological pursuits. They are employed also as managers or supervisors, as technical salesmen, and in top flight executive positions for which engineering training may not be a necessity but is a great aid.

This fact has been seized upon by several writers as a major cause of present severe shortages in technically-trained personnel. These writers call for a system which will insure that engineers pursue purely technological activities in their industrial employment. This, these critics argue, will significantly ease present shortages of engineers and scientists, result in increased job satisfaction for technical people, and promote "more efficient" utilization of technical manpower.

Counseling Has a Place

Fortunately for industry, the reasoning behind the above arguments has been recognized to be fallacious. Engineering educators, by and large, have been gratified at the versatility shown by their progeny. Steps have therefore been taken to modify engineering curricula toward better industrial preparation for young engineers.

This effort certainly has been in the right direction. It needs to be accompanied, however, by equally intensive efforts to increase the participation of engineering educators in the guidance and counseling of students.

The word *counseling* may have unfavorable connotations for many of the readers of this paper. Examples of poor counseling are numerous. Inexperienced, poorly trained, and often maladjusted persons posing as "counselors" have, by their abortive efforts, misguided the destinies of countless individuals. Fortunately, however, the bulk of professional counselors are competently and quietly continuing to do an effective job.

They are taking steps to purge their ranks of the undesirable elements mentioned above. Let it be known at the outset, therefore, that the author has heard of, recognizes, and sincerely deplores the many instances in which the counseling function has been seriously degraded. This is not to say, however, that *good* counseling is not desirable and necessary.

Expert guidance and informed counseling promote close working relationships between faculty members and members of the student body. It is important indeed that engineering

students have ready access to the advice and guidance which only informed and experienced faculty members are qualified to give. Through such relationships the student gains a realistic view of the industrial world which he is preparing to enter. His educational career also takes on new meaning. Course offerings become more interesting and vastly more palatable. Purpose and direction are added to the enterprise, and the student hearkens to the excitement of planning the journey toward his goal.

Granted that the guidance function is desirable and necessary in modern day engineering education, what are the major guidance problems to be faced? What methods may be most useful and appropriate in carrying out these guidance functions? Finally, what aids are available to give the faculty counselor added information about the individuals he is advising?

Are Engineers Dissatisfied?

Several writers[1] have speculated about matters which, when taken together, might be referred to as "the engineer's plight in industry." It has been said, for example, that engineers in industry suffer from chronic dissatisfaction. It has been said further that a major part of this dissatisfaction stems from a basic conflict between management methods and the scientific methods employed by the professional engineer. Actually, many of the points made by persons writing in this vein are based on faulty reasoning. It is a simple matter to point up some of these errors. Doing so serves to highlight some of the areas and problems requiring special attention from engineering educators.

(1) First of all the term "professional" is bandied about far too freely. A young engineering student, if he is to believe much of what he reads, will be lulled into feeling that possession of an engineering degree automatically carries with it the stamp of "professional engineer," thereby entitling the holder to much of the recognition, status, and privileges implied by the term "professional."

Bombarded by these arguments and quickening to the sweet taste of professional privileges, the engineering student needs to know and appreciate the broader connotations of the term "professional." Most of all, he needs to become aware that true professional status does not derive from such artificial (though important) supports as college degrees, group membership, and secret terminology. Moreover, he needs to learn about the duties as well as the privileges of professional status.

For example, he must take unto himself his profession's code of ethics. He must learn that first allegiance is not to himself, but rather to his profession, his employer, and to society. Recognition that the achievement of professional status is not a "cut and dried" affair, that it is a goal to be won through long and constant effort, will significantly lower the expectations of the young engineer who is about to enter industry. Giving engineering students a more realistic view of themselves and their profession is one primary need that engineering

[1] See for example, George Odiorne, "The Trouble with Engineers," *Harper's Magazine*, January, 1955, pp. 41–46, and David G. Moore and Richard Renck, "The Professional Employee in Industry: The Unhappy Engineers," IRC publication IV, University of Chicago, 1952, pp. 9.

educators, in carrying out their guidance function, can fill.

Engineers Differ

(2) Just as serious, possibly, is the prevailing notion that engineers are all the same, that they are of a certain mold, and can be handled in a definite, readily prescribed manner. Fortunately (or, unfortunately, depending upon your view), such a stereotype is far too simple. As has been mentioned previously, engineers carry out a variety of job duties ranging from top-flight administration to routine analysis and testing. Obviously, individuals possessing different patterns of abilities, interests, and personality traits differ sharply in the extent to which they are suited for these various functions. Because different engineers are differently "suited" to carry out various functions, instances of serious waste or misapplication of technical manpower are not uncommon. For example, an engineer may spend years in unsuccessful pursuit of graduate training, a career in sales engineering, a career in research, or some other engineering specialty. Needless to say frustration, dissatisfaction, wasted effort and time are the unwanted by-products.

Educators Need Assessment Techniques

Taking these facts into account, it behooves the engineering educator to familiarize himself, as best he can, with all methods applicable to the measurement of engineering aptitudes, interests, and personality traits. Supported by *objective* and *valid* methods of appraisal, the guidance burden will be significantly eased. Working with the student, the faculty advisor will be able to do a better job of pointing out the area or areas in which the student may expect to be most productive and satisfied.

In fulfilling this guidance function, psychological testing can play an important part. Unfortunately testing has received a bad name for several reasons. Chief among these is that most tests have not been appropriate for the measurement of the highly specialized abilities and interests possessed by engineering graduates. Thus, use of inappropriate tests, often administered and interpreted by poorly trained technicians, has resulted in attaching a general stigma to the entire testing approach.

Furthermore, many test makers have failed to provide sufficient evidence bearing on the validity of the tests employed. In other words, they have been unable to show how test scores are related either to job effectiveness in different industrial functions, or to the relative success with which different engineering students pursue their undergraduate or graduate studies.

Thus, the widespread use of inappropriate and poorly validated tests has served to discredit the testing movement—at least, so far as the testing of engineering students is concerned. Recognition of these shortcomings has led to an extensive personnel research program designed to develop *good* objective guides which may aid the engineering educator in accurate occupational analysis. The research program has addressed itself to the following questions:

- How do engineers who perform varied functions differ from each other?
- How can these differences be identified and measured?

- Which differences are most important in determining success or failure?
- Finally, can such differences be reliably measured? If so, can these measures be used to predict where a given individual will do the best job?

New Test Measures Engineering Achievement

The first step in the research program was the development of a high level engineering achievement test, the *Minnesota Engineering Analogies Test* (MEAT).[2] This test is the result of efforts to combine features of an abstract reasoning test with those of a comprehensive engineering achievement test. It is an attempt to build an engineering ability test which will accurately identify high level engineering capacity and which will be *acceptable* to the engineers who take it. Preliminary research suggests that this effort has met with substantial success. For example, engineers doing different types of engineering duties characteristically score differently on MEAT. This is an important finding because it shows that scores on this test may give some clues about where a young engineer might do his best job. Figure 1 shows how this works.

This figure shows the middle fifty per cent of scores for three groups of engineers engaged in different engineering duties. A quick glance at the chart reveals that pure research engineers score highest, followed in decreasing order by development engineers and sales and technical service engineers. This information can be useful in the guidance of engineering students and applicants for admission to engineering.

Suppose a young man scores 37 of a possible 50 on MEAT. It is obvious that he is well above the average of pure research engineers. Based on his engineering knowledge and his ability to reason abstractly, an estimate is warranted that he will make a top-notch pure research man. On the other hand, a second engineer scoring 28 on MEAT might be fairly typical of development engineers. The odds are that he would serve efficiently on a development job, but that he might be somewhat less effective as a pure research engineer.

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[2] Minnesota Engineering Analogies Test consists of problems of the four-alternative multiple choice variety in analogy form. Examples of some of the problems in the test include the following: (The correct answers are italicized)

(1) Add : Subtract :: multiply : 1) integrate 2) *divide* 3) magnify 4) differentiate

(2) In a triode,
Spectators : turnstile :: plate current : 1) cathode 2) plate 3) anode 4) *grid*

(3) Rate of fluid flow : electric current :: pipe friction : 1) electromotive potential 2) *electrical resistance* 3) conductance 4) resistivity

In order to answer any one problem correctly, an engineer must know not only his subject matter; he must be able also to perceive and identify the appropriate relationships. Psychologists have known for a long time that his ability to perceive relationships is related in a subtle way both to general intelligence and to abstract reasoning ability. It is likely, therefore, that *Minnesota Engineering Analogies Test* is an effective measure not only of what an engineer knows, but also of how well he can use the facts he does know. Development of MEAT has been carried on over a span of three years during which over 1300 engineering students and employed engineers have taken the test. It has been published and is currently being marketed by Psychological Corporation, 522 Fifth Avenue, New York City.

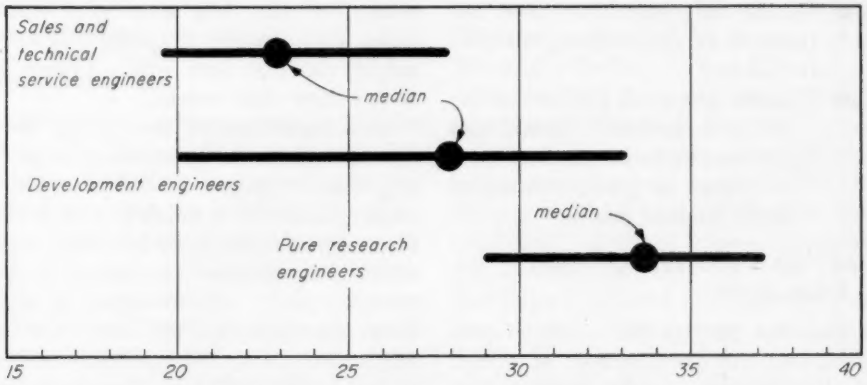

FIGURE 1. The middle fifty per cent of scores on Minnesota Engineering Analogies Test for three groups of engineers with different duties. Note that the median score for sales and technical service engineers is 23, for development engineers is 28, and for research engineers almost 34.

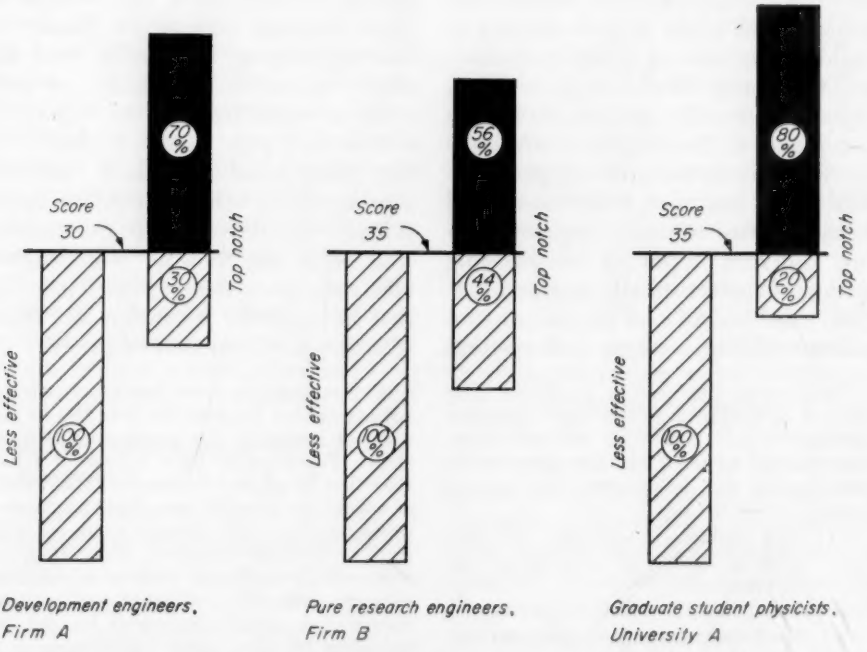

FIGURE 2. Per cent of superior and less effective engineers and students, above and below certain critical scores on the Minnesota Engineering Analogies Test. Note that in Firm A, 100% of the less effective development engineers scored below 30, while only 30% of the top notch men made 30 or below. The same division holds slightly less well with the research engineers of Firm B (100% against 44%), and somewhat more so with the graduate student physicists of University A (100% and 20%).

MEAT Validity Is High

Evidence bearing on the validity of MEAT is given in Figure 2. This Figure shows how scores on the test are related to engineering effectiveness as judged by supervisors of employed engineers and professors of students in graduate training. Supervisors and professors were asked to rank the engineers under them in terms of overall effectiveness. Figure 2 shows how well scores on MEAT discriminate between "top notch" (ranked in the top quarter) engineers and "less effective" (ranked in the bottom quarter) engineers. For example, in Firm A,[3] not one of the less effective development engineers scored above 30, but 70 per cent of the top notch development engineers did so. MEAT also does a good job among pure research engineers. In Firm B [4] none of the less effective pure research men scored above 35, but 56 per cent of the top notch research engineers did so.

Finally, it is apparent that the test also accurately identifies different levels of effectiveness in graduate training. None of the less effective graduate students in a group of M.A. and Ph.D. candidates majoring in physics at a well known southeastern university scored above 35, while 80 per cent of the top notch graduate students did so. Though scores on a test such as this certainly must be used with caution, evidence for the validity of the engineering test as a measure of effectiveness is impressive. Used in conjunction with other lines of attack, such as school grades, expressed desires, and general personality factors, this type of information can aid significantly in the educational and employment guidance of engineering students.

Measurement of Interests also Important

The development of *Minnesota Engineering Analogies Test,* therefore, may represent an important step toward supplying answers to the questions outlined earlier in this paper. This development has concentrated, however, only on the measurement of knowledge or aptitudes. What of the vocational *interests* or motivation of engineers performing different functions? It is logical to assume that a pure research engineer may differ sharply in interests from a good sales engineer. If this be so, objective measurement can give further important information for the guidance of the student.

[3] Engineers tested in Firm A were chemical engineers engaged in developmental research activities. None held a graduate degree.

[4] Engineers tested in Firm B were highly experienced electrical and electronics engineers engaged in pure research. Many held Master's or Ph.D. degrees.

[5] *The Strong Vocational Interest Blank* is a listing of 400 names, occupations, book and magazine titles, school subjects, and activities. For each item, a person taking the Inventory is asked to indicate whether he Likes, Dislikes, or feels Indifferent toward the item. Experience with the test shows that persons in the same occupation give similar answers. Thus the Inventory can be scored on how similar a person's answers are to those of successful men in any of 40 major occupations. Scores can be obtained for occupations ranging from carpenter and farmer to engineer, physicist, lawyer, or author-journalist. Extensive research with this test shows that a man's measured interests change little after age 20. They may be expressed in different ways at different times during his life, but the basic wants, desires, and propensities are strikingly constant.

As a matter of fact, preliminary research with the *Strong Vocational Interest Blank*[5] shows that measurement of interests can predict future engineering effectiveness. One study of interests showed that research engineers characteristically obtain markedly different results from those of sales engineers. Top research engineers showed measured interests similar to those of physicists, chemists, and mathematicians. Top sales engineers, on the other hand, were more like sales managers or real estate salesmen in measured interests. The most significant finding was that the research engineers who were rated as most effective by their supervisors were those who also scored highest on the basic science occupations (physician, chemist, physicist, mathematician).

These findings with the *Strong Vocational Interest Blank* are of special significance. They show that an engineer's interests (quite apart from ability) may be important in determining where he will do the best job and how good a job he will do. Research is now being directed toward determination of the characteristic patterns of interests shown by engineers performing different industrial duties, such as pure research, production, sales, and administration. It is hoped that when these data have been collected and analyzed, valuable added information will be available which can help in pin-pointing the type of engineering function most suitable for the young engineer. Such knowledge, obviously, could significantly ease the guidance and counseling problems faced by engineering educators. Objective information, based on acceptable tests with *proven validity,* can be applied both by engineering students and their advisors in planning educational programs appropriate to demonstrated basic abilities and interests.

ASEE PROCEEDINGS VOLUME FOR 1954-1955

Volume 62, 1955, of the series, *Proceedings of the American Society for Engineering Education,* all text material of the JOURNAL from September 1954 through June 1955 (excluding the annual meeting program and the directory of members) is now available from the headquarters of the Society. The *Proceedings* are prepared substantially by omitting the covers, advertising, and other ephemeral pages of the monthly JOURNAL editions. The cost of the bound volume, 832 pages, with four pages of subject index and two pages of author index, is $6.00. Orders and remittances should be sent to ASEE Headquarters, University of Illinois, Urbana. Copies are supplied without charge to associate institutional members.

MIT'S ENGINEERING PRACTICE SCHOOL—AN EFFECTIVE TRANSITION TO MATURE ENGINEERING

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In the over-all education of engineers there is a rather ill-defined period between the time when formal college education ceases and when an individual attains the position of a responsible, practicing engineer. It is in this period that there may be a sharp transition from the academic approach to the industrial approach. It is also in this period that there may be some loss in enthusiasm or morale as it becomes obvious that most subjects at school were considered on an "ideal" basis and that this basis usually is not directly applicable in practical situations due either to the complexity of actual problems or to the paucity of the data necessary to obtain an answer. Judgment, common sense, the ability to make simplifying assumptions, must be brought into play. These assumptions are not guesses—but intelligent approximations based on the theory learned in college. It is also at this point that many less technical virtues are emphasized, such as the ability to communicate effectively, and the ability to work within a group undertaking.

This transition period may be said to end in the development of a mature engineer, and until recently the course of this development has been left almost completely to the individual. Now, however, there is an awareness in industry that there should be a type of education which would accelerate the development of maturity in the engineering profession; an engineering internship might be appropriate. That this is industry's feeling may be verified by the newly placed emphasis on trainee programs. Some of this feeling has also sifted back into the colleges and may be noted by the growth of cooperative programs and in much of the course work wherein applications of theory are stressed.

At M.I.T. an Engineering Practice School program is offered, which it is believed decreases the transition time required to adjust from the college classroom type of work to that encountered in modern industry. The mechanism and aims of this program are discussed here and compared both to the collegiate cooperative program and to the type of training program sponsored by industry.

Industrial Training Programs

The report, "How to Train Engineers in Industry," which was issued recently by the Professional Engineers Conference Board and the National Society of Professional Engineers, has clearly emphasized the growth of industrial training programs. The general keynote of the report was that at the present level of wages paid to new engineers,

coupled with the shortage of engineers, it is economically advisable to accelerate the development of a new employee's professional potential by some sort of planned training program. R. P. Dinsmore [1] has said that the employer obtains "young men (who) have the favorable characteristics of being energetic, optimistic, enthusiastic, flexible in their ideas, and last, more durable than older men. On the other hand they are likely to exhibit the unfavorable characteristics of being unseasoned, underdeveloped in judgment, rash, inexperienced, undiplomatic, shortsighted, and weak in team spirit."

Although industrial training programs vary considerably in scope and in quality, the teaching techniques are, in most cases, not formalized but usually involve one or more of the following: role playing, job rotation, conferences, study courses. Many industries also aid employee engineers in obtaining advanced courses or degrees at nearby colleges and universities. The point of interest here, however, is the fact that by detailed programming, industry has found that it is profitable to "educate" the engineering graduate into the ways of competitive industry. This post-graduate or pre-industrial education involves not only the usual introduction to company policies but also the development of thinking and action reflexes as applied to practice.

The advantages of such engineer training both to industry and to the engineer trainee are obvious. The industry benefits at an earlier date from the engineer who is capable of undertaking responsibility, and the engineer enjoys an earlier professional, and financial, recognition. The main disadvantages of the programs lie not in the idea but in the application. Most programs are administered with little close supervision and the teacher is more often than not a line supervisor who has this added responsibility thrust on him in addition to his other duties. By no means is such a teaching method inherently bad—it may, however, be inefficient since there are many occasions when the supervisor has neither the time nor the experience to evaluate and guide the development of the young engineer.

[1] *Chem. Eng. Prog.*, 50, 109 (1954).

Cooperative Programs

Cooperative programs ordinarily provide excellent educational opportunities for young engineers. By combining classroom theory with practical application in alternating periods of time, a man quickly learns the necessity and limitations of theory in practical applications. This type of training for engineers suffers one serious drawback—the possibility of having poor or uninterested supervision in the plant phase of the program. Occasionally a student will spend all or most of his time at a plant on one problem or one type of work with little educational development except a specific factual gain about the problem at hand. The ability to work with or lead a group, the ability to deliver a competent technical talk or write a concise, clear report may or may not be developed, since the choice of problem and method of presentation is almost wholly at the discretion of his immediate supervisor.

There are some very conscientious supervisors who do their utmost to guide and help the trainee in his work, but unfortunately there are many, as in the case of the industrial

programs, who have neither the time nor patience to help, encourage, and criticize constructively the engineer trainee. Most universities or colleges with cooperative programs have a Coordination Department, the duty of which is to keep aware of what kind of work the students are engaged in. This is a step in the right direction, but until the immediate supervisor can be convinced of his duty to guide and encourage the cooperative student, maximum utilization of the student's time, for the student's benefit, cannot become a reality.

M.I.T.'s Engineering Practice Schools

The Massachusetts Institute of Technology has long realized the need for cooperating with industry to develop individuals who not only had a reasonably good background of fundamentals but also possessed other desirable traits such as the ability to reason, to express oneself orally, and to express oneself in writing. A tried and successful method used to develop these latter qualities has been the Engineering Practice School.

Undergraduate or graduate students may enroll in a one-semester course which is designed to be both intensive and comprehensive. For Chemical Engineering Practice, the student has a choice of three different plant areas: Hercules Powder Company at Parlin, N. J.; Eastern Corporation at Bangor, Maine; and Bethlehem Steel Corporation at Lackawanna, New York. The *Oak Ridge Engineering Practice School* is located at the Union Carbide Nuclear Company installation in Oak Ridge, Tennessee. The *School of Chemical Engineering Practice* is primarily for undergraduate and graduate chemical engineers; the Oak Ridge Engineering Practice School is attracting graduate chemical, nuclear, electrical, and mechanical engineers, as well as graduate science students in physics, chemistry, and metallurgy. Both schools are nearly identical in operation, so only one, the Oak Ridge Engineering Practice School, will be described here.

Aims of the Practice School

According to the late Prof. W. H. Walker of M.I.T., acquiring a knowledge of science is easier than applying this knowledge intelligently and successfully to the solution of technical problems. In recognition of this fact, the primary objective of the Practice School is to develop the student's ability to apply fundamentals by assigning him to a variety of challenging plant problems. Emphasis is placed upon the development of abilities to apply basic principles and good common sense to the solution of technical problems encountered in industry. At the same time, particular emphasis is placed upon the development of skill in public speaking, technical writing, group cooperation, leadership, and economic analysis.

Mechanics of the Program

The aims and purposes of the Practice School are put into action in an unusual way. A resident staff, consisting of an assistant professor and an instructor, is maintained at each station and is responsible for the education of the students. The staff surveys the current plant problems and judges whether they are acceptable by two criteria: (a) are they educational, requiring originality or creativeness of the students and (b) will it be possible, in the time allotted, to achieve results of value to the plant?

If a problem is judged suitable, two or more students are issued a memorandum describing briefly the background of the problem and the specific information desired; a plant consultant is also listed so that the students will have a direct liaison with the industrial staff. The problem may last from a few days to several weeks. The average time at Oak Ridge is two weeks. Thus each student will be assigned eight or nine different problems per semester.

In no case is a man assigned to a problem alone, for cooperative effort is one of the factors stressed in Practice School work. In sections of three or more men, a group leader is appointed who is responsible for coordinating the work and seeing that the assignment is completed on schedule. The responsibility of being a group leader for an assignment is rotated among the men.

A record is kept of each assignment so that each student will have different kinds of problems during the semester. The five general classes are: research, development, design, production, and technical service. By working in these areas the young engineer can evaluate his own potentialities and will be able to orient himself with regard to the type of future employment for which he is best fitted.

A few problems assigned may involve only a theoretical or economic study, but over half require some kind of experimental measurements. Because the experimental problems encountered at Oak Ridge may vary from a delicate physics experiment to the construction of a chemical engineering pilot plant, the Practice School is provided by Union Carbide Nuclear Company (subcontractors to the AEC) with a large laboratory and well equipped machine shop.

Solution of the Problem

Each group or team has the responsibility for the solution of its assigned problem. The first step in the solution of the problem is to become acquainted with the existing theory, operations, and equipment involved. Then the phase of the problem to which the investigation will be confined must be determined. These decisions may be accomplished by conferring with the plant men for their ideas and by consulting the literature, including plant reports, to determine what information is already available. Once the specific problem has been defined, it must be analyzed to determine the experimental data and test equipment needed, the precision required, the results expected, and the method of presentation.

The group then presents its plan of attack to the staff for approval. The staff makes criticisms and suggestions, but as far as possible the final decisions on the procedure are left to the students. After a plan which is acceptable to both the students and the staff has been outlined, it is taken for approval to the plant supervisor in whose division the work will be done.

Following this approval, the necessary experimental equipment is built and the actual test is performed. The assignment is complete when all results have been analyzed and the conclusions and recommendations have been properly submitted in a written report. Throughout, the importance of scheduling properly to meet the completion date is emphasized.

At Practice School it is emphasized that engineering is a group undertaking, and achievement may hinge

strongly on effective communication among the men in the group, so that the results of a technical investigation have little utility unless they can be understood and used by others. Thus, the students realize that it is of prime importance for an engineer to develop the ability to present technical reports with clarity, conciseness, and forcefulness, since others will often judge ability by the quality of presentation. It is also pointed out that just as one can command respect from his readers with a well-written report, he can impress an audience even more with a good talk. In the oral situation, he has considerably more chance to use the forcefulness of his personality in transmiting ideas.

Practice School men gain facility in writing by reporting the results of their investigations. An assignment is not complete until an acceptable written account of the work has been submitted. When the first writeup is turned in, it is reviewed by the staff for such points as scientific and engineering content, clarity and logic of text, completeness, grammatical construction, and form. It is then returned with a list of criticisms and suggestions. After being revised by students, it is resubmitted. This process is continued until the writeup is in a satisfactory form, after which it is reproduced and distributed to interested plant and laboratory personnel.

When each problem is completed, an oral report also is given by the group leader. The presentation is criticized freely both by staff and students. The ability to deliver a better-than-average oral report is so essential that, in addition to the reviews given after completion of the problems, several additional seminars are scheduled throughout the term. These talks, which may be either on optional or assigned subjects, are recorded so that the speaker can play them back later and judge his own style and delivery.

Students get further realistic experience in oral reporting when summaries on their investigations are presented for the benefit of plant personnel. The question period which follows is important, for it tests the speaker's grasp of his subject and his ability to give promptly a direct and satisfying reply to a specific question.

There is no formal grading scheme, but the final evaluation represents a composite opinion of the staff, fellow students, and consultants. Cooperation, leadership, self-reliance, and other such qualities are weighted equally with technical competence.

The Practice School approach may be summarized by noting a paragraph in R. L. Wentworth's paper in the 1951 Engineering Society of New England Essay Contest, "The graduates of Practice Schools have developed an alertness to practical problems that makes them immediately valuable on the job. For example, knowing how and where to buy steel stock can be of equal value with knowing how to determine its physical properties. But strangely enough, this kind of information, which can be picked up without much more effort than keeping the eye and ear open, is usually neglected. The common phrase to described this property is 'well-rounded.'"

THE INTEGRATION OF ECONOMY CONCEPTS IN THE CHEMICAL ENGINEERING CURRICULUM

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A paper presented at the 63rd Annual Meeting of the ASEE, Pennsylvania State University, June 22, 1955.

In order to determine the extent to which economy concepts have been integrated into the chemical engineering curriculum, we made a survey of all Departments of Chemical Engineering in the United States and Canada. A brief questionnaire was sent, asking:

(1) What courses *specifically* dealing with the economic aspects of chemical engineering and/or the chemical industries are included in your curriculum?

(2) Were such courses given in 1946 (ten years ago)?

(3)If there are no such courses, how are economic aspects introduced into the curriculum?

The return of completed questionnaires was outstanding. From our experience in mail interviews, a 30 to 40 per cent return is considered excellent. In this case, 80 per cent of the chemical engineering departments completed and returned the questionnaires (or 100 out of a total of 125 departments in the United States and Canada)—this despite the fact that they were busy with final examinations, grades, and graduations. The cooperation of the schools—in most cases the Department Chairmen—deserves our thanks and commendation.

By their own evaluation, 63 of the Chemical Engineering Departments reported that they currently offer some course which *specifically* deals with chemical engineering and chemical industry economics. This is about a 20 per cent increase over the past decade.

However, upon closer examination, we found that many of the courses listed actually were straight-forward engineering subjects (such as EQUIPMENT DESIGN), into which some economic considerations are integrated. On the other hand, quite a number of the schools which reported negatively do list technology courses which include some phases in the economics of chemical engineering. Such classes are considered as "PARTIAL" coverage.

On this new basis, 44 schools have specific economics courses, another 48 present the subject "partially," while only 8 departments report no efforts to integrate economy concepts into their curriculum.

A review of the titles of such specific economics courses in chemical

TABLE I

ECONOMIC SUBJECTS TREATED IN 52 CLASSES IN CHEMICAL ENGINEERING ECONOMY

Process Evaluation	80	*Management*	28
Production Cost Estimation	16	Financing	7
Investment Cost Estimation	13	Principles of Management	6
Alternate Investments	12	Personnel Relations–Labor	4
Optimum Design	11	Development & Organization of the Corporation	4
Process Evaluation	10	Accounting	3
Economic Balance	8	Break-even Points	3
Profits–Payout Time	7	Interest	1
Replacement Costs	3		
Business	25	*Commercial Chemical Development*	15
Marketing, Market Research	10	Patents	8
Industry Surveys	6	Research Economics	4
Raw Materials	2	Principles of CCD	3
Competition	2		
Sales Costs	1		
Prices	2		
Transportation	2		

engineering is interesting. The 44 schools listed 52 specific courses. There are 22 courses called CHEMICAL ENGINEERING ECONOMICS or ECONOMY. Eight are designated as ECONOMIC BALANCE. Four are called ECONOMICS OF THE CHEMICAL INDUSTRY or simply CHEMICAL INDUSTRY. Three are CHEMICAL ENGINEERING COST EVALUATION or ANALYSIS. Another three cover the subject under CHEMICAL ENGINEERING PROBLEMS. Two courses deal with CHEMICAL ENGINEERING or TECHNICAL ADMINISTRATION. Other titles listed by the various schools are:

THE BUSINESS OF CHEMICAL ENGINEERING
FACTORS IN CHEMICAL ENGINEERING
CHEMICAL ENGINEERING PLANT ECONOMY
ECONOMICS OF CHEMICAL MANUFACTURE
ECONOMICS AND DESIGN
PRINCIPLES OF ENGINEERING INVESTMENT AND ECONOMY
BUSINESS OPERATIONS IN THE PROCESS INDUSTRIES
PLANT LOCATION
PATENT LAW FOR CHEMISTS AND ENGINEERS

One course is called ECONOMIC ASPECTS OF PETROLEUM PROCESSING AND PETRO-CHEMICALS. Ordinarily, you would expect this to be given in one of the Texas schools. Actually, it is a required undergraduate subject at the University of Pittsburgh. As a matter of fact, the five Texas schools which responded indicated no specific economics courses in their Departments of Chemical Engineering. This may be due to the fact that money and raw materials may be so abundant in their area of interest that ordinary economic practices are superfluous.

Obviously, the greatest emphasis is placed on economic evaluations of chemical processes. Such subjects as Cost Estimation, Economic Balance, Profits and Payout Time are stressed. Next in importance seem to be management problems, such as Financing the Corporation, and Break-even

Charts. Another category is here called Business, which covers Markets, Market Research, Competition, Sales and the other problems involved in actually making even the most efficient process profitable. Subjects directly related to Commercial Chemical Development are mentioned 15 times. It must be noted that this breakdown of the contents of these courses is incomplete, since not every one of the 52 classes was described in detail.

Such economic considerations most frequently enter into classes on EQUIPMENT DESIGN, PROCESS DESIGN, and ORGANIC and INORGANIC TECHNOLOGY.

These courses usually deal with techniques of estimating investment and production costs, examining the components of such costs, estimating profits and payout-time on a process or plant, examining alternate investment opportunities, depreciation of equipment, replacement economics and optimum designs (both from a technical and cost viewpoint).

These economic concepts are important. Unfortunately, all too often these are presented in the form of "ivory tower" problems, somewhat unrealistic to the average businessman and practicing engineer. For example, such economic appraisals often assume that a plant runs at 100 per cent of rated capacity. In actual practice, this is seldom the case. The practical engineer concerns himself not only with capacity operations, but must also know his costs when the plant is running at partial capacity or is being pushed beyond the rated capacity. The quirks of the customers seldom permit any unit to be operated at a uniform rate for any length of time, even with abundant inventory capacity.

Another business factor often overlooked is the fact that minimum costs may not give the maximum return on the investment. An additional refining step, for example, may give a vastly improved and more desirable product. This may involve additional capital outlays and greater production

TABLE II

CHEMICAL ENGINEERING COURSES WITH SOME INTEGRATION OF ECONOMIC CONCEPTS

By 48 Schools Which Give No Specific Ch.E.Eco. Courses

Design	37	Process Industries	3
Technology	10	General Ch.E.	3
Unit Operations	8	Comprehensive Problems	2
Industrial Chemistry	7	Energy & Material Balances	1

A few schools listed classes on related subjects given by other departments, such as ENGINEERING ADMINISTRATION by the Mechanical Engineering Department or ENGINEERING ECONOMY by the Economics Department. Such classes, however, cannot be considered as dealing specifically with chemical engineering economy concepts.

Process Evaluations

The foregoing survey highlights two facts: (1) that most Schools of Chemical Engineering incorporate economics—or rather a dollar consciousness—into some phase of their technical training, and (2) that such integration is mainly in the field of economic process analysis, cost estimating, and return of investments.

cost. However, the improved product may warrant a higher price, may find larger markets and result in additional income, higher profits and a faster payout-time than the minimum cost plant. This factor is often especially true in consumer products, where additional eye appeal may mean higher costs, offset by substantially greater sales and profits.

The optimum economic output of a plant need not be the sum of the minimum unit costs of the individual operating units. The production rate of an entire plant is often a balance of numerous inter-related and co-related factors, such as the efficient use of labor, utilities, sales costs, and storage costs. Optimum economics may depend upon the operation of various units at higher than minimum unit costs.

The problem of the old, "obsolete" plant and product is too often handled on a straight cost basis, whereas other factors may intervene. In many instances, a company will continue to produce a product on which it loses money, simply because it leads to profitable sales in related items. In other cases, the company will continue to sell the item to maintain a complete line of products.

Very often, company management will decide to ignore unfavorable costs and profits. The ability to enter the market first with a new product may eliminate many cost considerations. Securing the market may be more important than optimum returns. The Quaker Oats Company often sold its furfural at a price extremely close to—and at times lower than—costs. The company's double objective was both to stimulate new applications through low prices and to discourage possible competitors by low profits. This long-range approach to furfural production and sales has paid off and is paying off handsomely. Without direct competition, Quaker today sells about 150,000,000 pounds of the chemical.

Another factor not stressed in many of these courses is the human quality of "compromise." You may be able to produce a better product at just a few cents more per pound. Your customer, realizing that your product is much better than his present material, will still refuse to buy. A few years ago, an East Coast company bought out an excellent dielectric casting resin. It had excellent storage life, pot life, curing cycles, dielectric and physical properties. Its selling price was about 10 cents higher than competing resins. The manufacturer was sure that the improved properties justified this higher price. To his distressed surprise, large orders never materialized. The electronic component manufacturers recognized the added values of the resin, but refused to pay the additional cost simply because their present plastics were "good enough"—adequate to do the job.

Here is another problem in profits. Which is more desirable, a profit (after taxes) of $100,000 per year on an investment of $1,000,000, or a profit (after taxes) of $300,000 per year on an investment of $3,000,000? Both have an identical return on investment—10 per cent. The actual decision rests on many factors other than chemical engineering economics, such as:

The company's ability to raise money.

The activities of competitors in these two lines of business.

The possibilities of using these processes or products for future diversification.

The trend in the demand for these products.

The organization of the company—its ability to absorb either of these two products readily in its present production, research, sales and distribution set-up.

Government policies.

General company policies and aims.

Of course, the businessman seldom is faced with a situation where two projects have identical returns, but this example does highlight the need for looking further than just costs and profits in managerial decision-making.

The Business of Chemical Engineering

So far, we have seen that Chemical Engineering Economics too often just examines the means and the cost rather than the wants and ends. Markets are usually assumed for the products under consideration. It concentrates on a study of alternate investments and comparative cost studies. R. P. Dinsmore of the Goodyear Tire & Rubber Company recently stated:

"The transition to the industrial atmosphere from the classroom, the laboratory, and the university pilot plant—even though training has been supplemented by some industrial practice school experience—is rather a mental shock to the average engineer. He ceases to be dealing with people whose primary objective is to impart information to him, and instead he is in contact with people whose chief preoccupation is to do a job or a whole series of inter-connected jobs. He learns to his dismay that there are numerous people who do not think that chemical engineering is the ultimate of industrial or business activity and, in fact, he finds out that there are many highly placed people in industry who do not even consider the profession of chemical engineering to be an important means of achieving their business objectives. He learns that even among the practicing chemical engineers the highest type of classical chemical engineering practice is not always employed, and that on many occasions speed is given a far higher rating than precision." (2)

The problems of the young engineer were also well expressed by George Odiorne of Rutgers University in a recent article in *Harper's Magazine*.

"It is on graduation from school that the engineer finds adjustment most difficult, for it is here that he must begin the process of 'unlearning.' Idea by idea, he must clear his mind of 'pure' engineering to make way for such mundane considerations as cost, market-ability, consumer foibles, company folklore, union contracts, and the personality quirks of the chief engineer. In short, all the finely tooled and delicately adjusted machinery that keeps society going." (3)

Giving the chemical engineering student a taste of the business world is a difficult problem—as difficult as making an engineer out of a high-school graduate. Cost consciousness is already well integrated into his curriculum in most schools. But industry has other requirements for the future engineer. To give the average student some insight into the "cat and mouse" existence of industrial activities, a number of Departments of Chemical Engineering have introduced into their curriculum survey courses specifically designed to accomplish these ends. Such courses cover a wide range of subjects, from the ability to communicate to market analysis and marketing to sales and advertising.

Typical Courses

At Cornell University, the Department of Chemical Engineering offers a course called Chemical Engineering Economics. The stated objective of this course is to:

". . . acquaint the student with many of the economic problems involved in the development and operation of chemical industries. Emphasis is placed on the organization of a chemical company and on the function of the various divisions of a chemical company. Estimation of development, construction, and operating costs is also stressed."

The course is divided into ten parts, starting off with a discussion on The Economic Characteristics of the Chemical Industry and The Role of the Chemical Engineer in Industry. This is followed by the following subjects:

- Return on Investment
- Research Economics
- Estimation of Manufacturing Cost
- Sales Expense
- Transportation and Delivery Cost
- Chemical Prices
- Management in the Chemical Industry
- Sources of Capital

Dr. James Boyd gives an undergraduate course at Columbia University called The Business of Chemical Engineering. This one semester class features speeches by leading chemical businessmen on different aspects of chemical economics. The organization of Dr. Boyd's class is as follows:

- English, An Engineering Tool
- Chemical Research Costs
- Costs in Process Development
- Commercial Development Practice
- Selling Fine Chemicals
- Opportunities for Engineers in the Petroleum Industry
- Selling Industrial Organic Chemicals
- Cost of Chemical Advertising and Public Relations
- The Study of Diversification Opportunity
- New Plant Economics
- Plant Capacity Versus Earnings
- Cost of New Capital

A similar class is given to seniors in chemical engineering at the Polytechnic Institute of Brooklyn, called simply Chemical Industries. The stated aim here is a

"Study of the fundamental economic aspects and organization of the chemical process industries, with special attention to the problems encountered by the practicing chemical engineer. Consideration of the background of the industry and the inter-relationship between research, production, and sales with sources and supplies of raw materials, principal and by-products, and the influence of transportation costs. The preparation of surveys, cost analysis, estimates, and patent protection."

Again, the course starts off with a discussion on the Background of the Chemical Process Industries, followed by a treatment of the following subjects in Table III.

In retrospect, these courses deal not only with what is commonly called Chemical Engineering Economics, but extend their scope to include a survey of the most important aspects of carrying on a chemical business. The stress is on the selling of the products which the chemical engineer

TABLE III

OUTLINE OF CH.E. 217—CHEMICAL INDUSTRIES

Polytechnic Institute of Brooklyn

BACKGROUND OF THE CHEMICAL PROCESS INDUSTRIES

THE MANAGEMENT REPORT
- The Technical-Economic Report for Management.
- Sources of Information.

THE CHEMICAL COMPANY
- Development and Organization of the Process Company.
- Managerial Practices and Evaluation.

PROCESS EVALUATION
- Cost Estimating and Cost Analysis.
- Economic Balance.

PRODUCT DEVELOPMENT AND MARKET EVALUATION
- Commercial Chemical Development.
- Chemical Market Research.

SELLING CHEMICALS
- Marketing of Chemicals.
- Distribution of Chemicals.

SPECIAL SUBJECTS
- Patents for the Chemical Engineer.
- Plant Location.
- Pricing Chemicals.

creates; or, in other words, giving the chemical engineering student an awareness of other business factors than the engineering or processing, which concern him most directly. Aside from becoming cost and profit conscious, the student learns the facts of business life—where and how sales are made—the sources of income—the problems of prospering in our demand and supply economy.

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(2) Dinsmore, R. P., "Growing into Management Through Professional Maturity," *Chemical Engineering Progress*, V. 51, No. 2, pp. 72F–73F (Feb. 1955).

(3) Odiorne, G., "The Trouble With Engineers," *Harper's Magazine*, V. 210, No. 1256, pp. 41–46 (January, 1955).

OPEN SUMMER CONFERENCE ON MATHEMATICS IN ENGINEERING

The ASEE and the National Science Foundation will sponsor jointly a conference on Mathematics in Engineering, at the University of Michigan, Ann Arbor, on June 20–21–22, 1956. Information can be obtained from Frederick C. Lindvall, Chairman, Division of Engineering, California Institute of Technology, Pasadena, California. Topics to be covered will include probability, statistics, numerical analysis and computers, operations research and systems engineering, continuum mechanics and field theory, and the impact of mathematics on engineering and scientific education.

Arrangements chairman is Professor C. M. Thatcher, Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor. Correspondence concerning reservations and requests for detailed programs should be directed to him.

MECHANICS TEACHERS—THEIR CROSS AND THEIR CROWN

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A paper presented at the Mechanics Division luncheon, Pennsylvania State University, June 22, 1955.

Teachers of engineering mechanics not only bear a burden of responsibility in teaching, but also enjoy a reward for the effort expended. Our responsibilities are three-fold. We must (1) impart a knowledge of Newtonian mechanics and engineering methodology, (2) develop and adapt new fields of science for engineering to replenish older ones absorbed by regular curricular subjects, and (3) develop scholars with a professional consciousness, so that our industrial supremacy can continue to protect our way of life and increase the jobs available for a growing population.

Our Responsibilities

Teaching Mechanics. Imparting knowledge of Newtonian mechanics can be either dull and routine or inspiring and creative for the student. Alert teachers are always simplifying the presentation of subject matter and introducing more generalized treatments of advanced topics. The use of partial derivatives and vector analysis, or the introduction of virtual work and varying mass illustrates a few such recent changes in undergraduate courses in mechanics. If, however, our objective embraces the dual responsibility of preparing students for creative design as well as for advanced courses in engineering science, our approach will have to undergo even greater transformation.

At present we limit our presentation to two-dimensional problems in motion or states of stress. Seldom do our beginning courses mention the thermodynamic effects on solids during loading or unloading cycles or give the student a notion of strain in terms of a space derivative of displacement. I realize the pedagogical difficulties involved, but I am amazed at the lack of experimentation in education. Anyone who has been fortunate enough to join ECPD accrediting teams must have become aware of the identical manner in which mechanics is presented throughout the country. All schools include or exclude similar topics. It is difficult to understand why as many energetic young minds as mechanics teaching has attracted should be so lock-stepped.

Various schools have made tremendous strides in the past several decades by introducing graduate work in mechanics. All too frequently, however, older curricular departments have been slow to incorporate this course work as a minor for the graduate programs of their own students. *A wider perspective than the present one is badly needed. Perhaps it can be realized only by a dissolution of* traditional departmental barriers and

academic empires that are still all too prevalent in the engineering educational environment. Engineers of the future will need a much broader training in all of the basic and engineering sciences.

Perhaps the heavy teaching loads, the large classes, the interest in sponsored research with its monthly reports, the increase in administrative red tape, and the need of finding supplemental summer employment have dimmed our reflective powers and retarded our progress. Certainly, they leave little time for the creative mental diversions which stimulate progress in education. A few years ago a well-known member of our group told me that he had entered teaching a generation ago because it offered a contemplative life, but that now he could afford time for a vacation only when undergoing treatment in a hospital. College administrators have a problem to face here; they must grapple with it if engineering education is to keep pace with the continuing discoveries in science.

New Sciences. A responsibility also exists to adapt new fields of science to engineering education. There is no reason why mechanics should not bridge this gap between science and engineering.[1] The mechanics teacher has been responsible in the past for introducing classical elasticity, dynamics, and fluid flow into the engineering curriculum, modifying them and expanding their scope with studies in plasticity, vibration, and transsonic flow. Much of this theory has been absorbed by the more applied courses of traditional curricula, thus strengthening their creative approach. History will continue to repeat itself, and we mechanics teachers will have to exploit new sciences to continue our mission or we will ultimately find ourselves trying to defend an outmoded status quo. *"Revise or retire"* could well be our motto.

Acceptance of this mission could well be a most invigorating challenge. Present-day needs cry for a new approach to the field of engineering materials, embodying the fundamentals of physical chemistry and solid state physics, for the introduction of statistical methods in laboratory experiments, and for instruction in use of digital and analogue computers of both mathematical and physical simulator types. These and other pressing requirements present an opportunity for alert young teachers to serve their calling and enhance their own reputation.

Modification of the discoveries in science for use by engineering represents but half of our obligation. Any university exists as a community of scholars, not only to teach what is already known but to seek new truths as well. Hence, every teacher should be engaged in some research, basic or applied. Such activity will be reflected in and enliven his lectures, and will motivate his students to maximum effort.

Development of the Student. So far this discussion has dealt with the more tangible aspects of subject matter. The intangible effect on the student is no less our responsibility. We must and can spur a greater percentage of our students to develop inquiring minds and imbue them with a zest for scholarship. By example at least, we should inspire them to form a habit of life-long study that will keep them abreast of expanding fields of

[1] Paul F. Chenea, "Mechanics—The Bridge Between Science and Engineering," *ASEE Mech. Div. Bul.*, Vol. V, No. 1, 1954.

technology, to develop a professional consciousness that will avoid unionization of our creative mission, and to broaden their interest in the historical and social heritage of our civilization.

Technical subject matter must, therefore, be taught as a segment of a broader culture; students must be regarded as bearers of the torch we hand them. These students of ours are the intellectual cream of this civilization. Too often we regard them as stupid when they fail to grasp the subject matter we teach. These failures may reflect our own poor presentation. We cannot just present material and fail the hindmost, yet we must uphold professional standards in the face of an apparent decrease in the adequacy of high school preparation. We must impart a knowledge of subject matter and a desire to continue self-study.

Our Rewards

Just as our cross can be subdivided into three broad responsibilities, so too can our crown be composed of three merited rewards. These might be regarded as (1) financial, (2) social, and (3) academic.

All college administrators are endeavoring to raise salary scales so that academic remuneration will more nearly compete with industrial income. Despite their best efforts, much of the improvement has frequently been too little or too late. It seems impossible for college salaries to keep pace with the three per cent increase in purchasing power our technological advance seems to bestow on civilization generally. This fact is rather ironic. I wonder at times whether the citizens of this country have the wealth to pay for the kind of education they say they want. I have faith, however, that this problem will ultimately be solved. Certainly, if the public and industry attack the economic problem as vigorously as we do technical ones, the solution will be forthcoming. It must be approached on a long range basis so that the best engineering minds will continue to be attracted to teaching in ever increasing numbers. Things have not been too bad so far, at least in larger schools, and I am sure that more than a few deans would testify to the fact that at least a few of us have grown fat and sassy on our salaries.

Socially, we have fared even better. Despite the never-ending stream of cartoons and jokes about absent-minded professors, we do enjoy a position of respect in our community and among our professional colleagues. We enjoy that element of security so necessary for creative thought, and we live in a cultural environment that would be considerably more expensive to emulate outside of ivory towers.

Academically, too, we have much to be thankful for. Promotions have been continuous and even rapid for many of our number. Some have even been bold enough to accept the responsibilities as deans of engineering, thus forsaking their sheltered existence. That is a risk all young teachers have to accept. We have been priviledged to watch the students we trained in mechanics assume positions of responsibility in both the educational and professional world. These graduates and we ourselves are contributing immeasurably to the technical problems of our expanding economy and to its preservation.

SUGGESTIONS ON HOW TO TEACH "ENGINEERING SCIENCES"

SHELDON S. L. CHANG

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The committee "Report on Evaluation of Engineering Education" listed the following six topics of engineering sciences in its recommended curriculum:

1. Mechanics of solids (statics, dynamics, and strength of materials).
2. Fluid mechanics.
3. Thermodynamics.
4. Transfer and rate mechanisms (heat, mass, and momentum transfer).
5. Electrical theory (fields, circuits, and electronics).
6. Nature and properties of materials (relating particle and aggregate structure to properties).

It is suggested here that topics 1, 2, 3, 4, and 6 be combined into one single course, given in the following sequence:

a. mechanics of a rigid body
b. statistical properties of an aggregate of particles
c. heat, temperature, entropy, ideal gas law, first and second laws of thermodynamics
d. transfer of momentum, Navier-Stokes differential equations
e. properties of an aggregate of closely bound particles—elasticity and applications.

Item "a" will include translation and rotational motion.

Item "b" is an introduction to statistical mechanics in its classical version.

Items "c" and "d" are natural results of item "b". The Carnot cycle and actual operating diagrams can be taken up as application problems of item "c". The instructor may work out some examples and let the students do most of the others as homework problems. Similarly, laminar flow can be given as homework problems with some simplifying assumptions. The instructor may point out in the next class that such simplifying assumptions are not always true, and that the solutions to Navier-Stokes equations are not unique and give a qualitative description of energy balance in turbulent flow. This leads naturally to Reynolds number and similitude.

Item "e" is a natural contrast to item "b". Transfer and rate mechanisms can be given as application problems at proper stages.

My reasons for suggesting the above unified course are listed below:

1. It will give the students a deeper insight into engineering sciences.
2. It is usually easier for the students to absorb a few broadly enveloping concepts than to remember a lot of empirical formulas.
3. Being exposed at an early stage to the correlations between thermodynamics and fluid mechanics, the students are better prepared for advanced training.
4. If information theory develops to such importance as to warrant its

inclusion in "engineering sciences," it can be introduced as another branch of item "b" in the sequence.

5. As we are trying to teach more science and engineering in the same four-year curriculum, it may be desirable not to let the students realize the situation. Believing that they are asked to do no more than millions before them have accomplished, they will have greater confidence in overcoming the homework problems. It appears advantageous psychologically to 'sneak' the topics in as a natural succession rather than as an increasingly extensive aggregation of separate courses.

One may object on the ground that the above approach presumes that the students are good in calculus. This is true. However, we may expect their calculus to improve as a result of working constantly on thought-searching problems.

Concluding the above, my suggestion is to present the engineering sciences in two courses:

1. *Non-electrical Sciences*
   Topics 1, 2, 3, 4, and 6 in the report, with optional inclusion of information theory.
2. *Electrical Sciences*
   Fields, circuits, and electronics.

ECRC REVIEW OF CURRENT RESEARCH

Primarily an outline of the current research program being conducted by experiment stations and research foundations of the 116 ECRC member institutions, the present volume is an important source of information about research policy and interests. It should be consulted not only by research administrators, but also by project personnel engaged in preliminary bibliographical searches. Arranged alphabetically by institutions, the 352 pages review research organizations and income, active projects, sponsors, and areas of interest or concentration, with members of research personnel active in each. Forty-six pages of *subject index* for research projects close the volume. So far as member institutions are concerned, these make possible ready location of fellow workers in a specific field.

Edited by Renato Contini, Secretary of the Engineering College Research Council, with an introduction by Harold K. Work, Chairman of the Council, both of New York University, the volume is available at $2.00. Orders and remittances should be addressed to Professor Contini, New York University, University Heights, New York 53. Copies would be useful both in research offices and in engineering or special libraries. Publication frequency is biannual, so that the present edition will be current until late spring of 1957.

A SMALL RESEARCH COMPANY LOOKS AT ENGINEERING EDUCATION

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A paper presented at the 63rd Annual ASEE Meeting, Pennsylvania State University, June 22, 1955.

Rather than posing as a spokesman for a particular branch of industry, I prefer to confine my remarks to certain observations with regard to the technical staff of HRB, a small corporation with about 250 employees. Our company is about eight years old, and started with essentially no capital and only a handful of employees. To build up to our present level, we have had to employ and assimilate each year a staff approximately equal to half of the then existing group. Our growing pains have been many, but not fatal. The business has been largely electronics development, although many projects undertaken have to do with the utilization of electronics rather than with electronic devices themselves.

Assessment

One approach to the subject of engineering education is to try to determine what the important qualities in our engineers are, and then to look at the relationship of these qualities to the engineers' formal college training. A quick check-off list includes the following:

1) Fundamental knowledge of engineering principles, physics, and mathematics
2) Ability to do original work
3) Ability to organize work, to meet time schedules, to estimate the difficulty of the job, and to communicate the results to others
4) Ability to supervise others, both technically and from the management standpoint
5) Enthusiasm for the job, pleasant disposition
6) Ability to satisfy management that the job is under control

Of the six factors listed here, only one or perhaps two can be classed as within the realm of engineering education. Surprisingly enough, of the several men whose performance at HRB did not justify keeping them on the staff, only one has been let go because of lack of technical knowledge. (Only about five men are involved here, so the figures have no statistical significance.)

Perhaps I should be addressing a group of engineering management specialists, or a group of psychologists, since most of my list of requisites has to do with non-technical factors. However, as we all know, a good basic knowledge of engineering is the *sine qua non* and unless the engineer has it there is no need to discuss the other factors, important though they may be. Before we leave the subject of non-technical factors,

I would like to put in a plug for making the engineering student aware of the importance of these factors in his future work. This need not be done in the classroom but can be accomplished through seminars and other evening sessions where representatives of industry are brought in and asked to tell the student what it is like "on the outside."

A series of such sessions at Penn State, where the seniors in electrical engineering are exposed to a number of outsiders who explain their jobs after being out of school 4 or 5 years, are certainly helpful and should impress on the student that it isn't only skill with a slide rule that counts.

Physicists vs Engineers

Since our company hires almost equal numbers of engineers and physicists, and uses them more or less interchangeably, we have an opportunity to see how they compare when exposed to the same kind of problems. Our work falls generally in the category which the trade calls "systems development"; most jobs are neither pure physics nor pure engineering. You might say that our work is too low-brow for physics, and too impractical for engineering. In any event, a team of engineers and physicists, usually abetted and hampered by a mathematician and sometimes by a psychologist, can normally find an acceptable solution to the problem at hand. In general, both the physicist and the engineer will provide valuable assistance to the project, and in about equal measure. Many of our engineers, however, would be at a loss in deciding how to begin complex analytical projects.

Since most of our physicists have a liberal arts background as opposed to the engineers' more regimented program, it is interesting to consider the effect of this difference on their performance. Our new engineers are usually more ready to do something "constructive" than the new physicists, the engineer being trained for something fairly specific, the physicist being merely trained in a few basic subjects.

The physicist is usually more versatile and more at home regardless of job assignment. Of course, almost all new men need close supervision and their growth during the period of the next 3 or 4 years probably has more to do with their success at our company than their college years. Our experience indicates that the physicist is more likely to develop into a good analyst and a good member of the development team, while the engineer is more likely to be weak on analysis but more aware of project scheduling, budgetary restrictions, and the like.

To determine what differences exist in the educational backgrounds of our physicists and engineers, we have conducted a survey of our employees. The results indicate that the physicists have over twice as many credits in basic science as the engineers.

The principal difference between the performance of our physicists and engineers lies in the field of analysis. Most of our difficulties have stemmed from not doing sufficient analysis before undertaking to build some device. If one device or approach is known to be satisfactory, it is easy to use that design or approach rather than to consider the advantages which might accrue to any of several possible alternatives. For this kind of operation, our physicists' training has stood them in good stead. Hence, I believe that more analysis could be

profitably worked into the engineering curriculum.

Another factor on which our engineers are weak is that of English usage and report writing. A job well done is not appreciated unless it is communicated to others. This involves several communication channels, but the most important in our business is the technical report. Almost all of our engineers demonstrate an aversion to writing a report and an inability to write a good one. Our survey showed that our engineers averaged only 10 credits of English, including short courses in American or English literature. There is apparently not enough emphasis on English usage in the engineering curriculum. I believe this situation is fairly serious and deserves the attention of those who establish engineering curricula. Incidentally, the aversion to writing reports is not limted to our engineers, but applies pretty generally to most of our employees.

To those who say that more time is needed to crowd in the technological details of an ever-expanding world of engineering, I say—let the details go. The student cannot possibly get them all in any case. Let him learn most of these later. Reserve his time for fundamentals such as physics, mathematics, and chemistry, but don't overlook English.

Of our seven or eight men who have had to work with transistors, none had any undergraduate training in the characteristics or use of these devices. They have all acquired their knowledge of transistors through study of published material, through experimentation at our laboratory, and through attendance at short courses offered by Penn State during the summer months. I cite this example only to show that the lack of training in this subject in college has had no bad effects on performance. The college years represent only about 10 per cent of the active professional man's life. It is not necessary to stuff him with enough information to keep him going for a lifetime. When the student enters college it is not so much a question of what he learns during the next four years as it is in what direction he will move for the next 40.

In Short

The proper equipment for an engineering graduate, as seen from my experience with a small research and development firm, is a sound background in the basic sciences, an ability to communicate his ideas to others, and an inquisitive nature which will cause him to remain a student throughout his professional career.

NEW LOWELL COURSE

Lowell Technological Institute, Lowell, Massachusetts, has established a new area of specialization, general engineering. The four-year course which leads to the B.S. degree in General Engineering was inaugurated to train graduates who would cut across the traditional lines of engineering specialization. Lowell Tech will be the first publicly supported college in New England to make such a course available to future engineers. The industries of Massachusetts have evinced great interest in this program and cooperated in its establishment. The new course will be available to incoming freshmen in September, 1956.

TRENDS IN ENGINEERING EDUCATION

The Case for a New Science Background

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A paper presented at the Syracuse meeting of the New York Section ASEE, on October 14, 1955

Three trends that affect all engineers have developed with particular rapidity during the past two decades: (1) the research-mindedness of industry, (2) the highly technical nature of recent wars, and (3) the consequent, or at least concurrent, research-mindedness of engineers. These have had the effect of vastly increasing the technology and experience within the engineering profession. Even more, they have been accompanied by great complexity in engineering projects and activities, to the point of requiring an almost new breed of engineers to cope with the demands of these projects.

This does not mean that there is a single pattern for all engineers, or that engineers trained in the older curricula have lost their usefulness. On the contrary, the number of jobs waiting for such people will be greater than ever before and many schools may quite properly choose to continue to train in that pattern. It does mean, however, that the shift in the spectrum of engineering activities demands that many engineers be trained for the new research functions that engineering now includes.

What are some of the characteristics and functions of the modern engineer? To begin with, he is more schooled, with more advanced degrees, than was the earlier custom; the doctorate is almost a prerequisite to responsible work in several of the engineering divisions. He is required to be fairly versed in mathematical methods, and does not hesitate to take courses of study that once were the domain of the physicist and mathematician.

His interests and problems have gone far beyond the limits of handbook technology. He has even had to give up his complete dependence on the pure mathematician and physicist for analytic techniques, since these people are too engrossed with their own advances to be of much help on engineering problems that are burdened with realistic details. Complex electrical and mechanical computational gadgetry have become his domain also.

As a consequence of all this, a remarkable blending appears to have taken place between engineering and the pure sciences. Just as physicists, chemists, and mathematicians of a few decades ago found that their research interests over-lapped when they got down to business on the atom, so now it often becomes difficult to determine from the subject matter and the treatment whether a piece of research should be conducted by a "pure" scientist or by an engineer. It has been repeatedly noted by educators that basic problems and basic

techniques of pursuit are becoming common to more and more disciplines, whether solid state research, high frequency electrical phenomena, aerodynamics, mechanical, or nuclear systems.

Perhaps the most dramatic example of this blending and extension of perspective has developed in connection with nuclear power. The role that engineers-turned-scientists have played in this development has not been sufficiently emphasized. Many of the basic concepts and techniques connected with gaseous diffusion plants and early nuclear reactor systems were developed by engineers.

Moreover, the engineer is gaining firm footing in this remarkable field. There is now much less dependence on the physicist and chemist to design the plants and components, or even to undertake research that will lead to improved reactor concepts and to improvement in the subtleties of reactor economics.

This points strongly toward a different type of training for engineers. Indeed I am of the opinion that the nuclear power program will be the greatest single factor in setting the pace and pattern of advanced engineering education for the next few decades, to a degree that goes far beyond the actual percentage of engineers engaged on nuclear work. This will be true partly because of the needs of the atomic program, but even more because the improved teaching and engineering concepts and techniques that accompany the nuclear program will in time supplant many of the less-cogent current methods.

The blending of interests and techniques has scarcely made itself felt in college catalogues, however, where one finds impressive duplications among such courses as thermodynamics, mechanics, fluid dynamics, structural analysis, and vibration. Engineering instructors seem scarcely to have found any common principles to influence their teaching; at least it seems much easier for a department to add its own new course than for several departments to join hands in cultivating common ground.

I do not know how this condition can be helped. The nuclear power program could improve the correlation and unification among the disciplines, unless we prevent this by setting up separated departments for nuclear engineering also. At R.P.I. we are pursuing nuclear engineering on the assumption that all the engineering and science divisions must contribute to the development of atomic energy, each with the emphasis corresponding to its research and educational interest in this broad field.

Weakness of Undergraduate Training

While specific engineering subjects can stand some further analysis, I would prefer to spend this time on the science background courses, namely physics, chemistry, and mathematics, which are offered to engineers. The controversy has been warm on the subject of the teaching of these subjects to engineers, with opinions running all the way from satisfaction with courses as they are now taught, to suggestions that engineers take over most of the job. Physicists themselves, under the sponsorship of the American Institute of Physics, have seriously studied the problem, and a report on the Role of Physics in Engineering Education has appeared. (*Editorial note: for the final version of*

the AIP report, see the March issue of the JOURNAL.)

While this Report contains good recommendations for improving the teaching of physics, I am not certain it adds the new approach that is called for. My own degrees were taken in physics and I am sympathetic to that approach, but I must nevertheless join with those who ask for a more effective presentation of physics to engineering students. However, I would not suggest that others take up the teaching job of the physicist, any more than non-chemists should teach chemistry.

The Report of the American Institute of Physics suggests that the most important contribution that physics can make to the training of engineers is to provide a knowledge and appreciation for (1) the methods that have been found effective in describing the way nature behaves, and (2) the concepts that have been derived therefrom. I am inclined to think that objectives stated in these words tend to encourage, rather than discourage, encyclopedic and historic details that submerge rather than reveal the fundamental laws of nature to those who are not physicists. Except as these concepts are recognized by the student to be the underlying and *unifying* principles on which the current engineering techniques find firm base, physics will not have done its work.

But therein lies the rub. The basis for engineering is not revealed by improvements in the teaching of physics alone, nor in the teaching of chemistry alone, nor in the teaching of mathematics alone. Actually a new science background is needed for engineers, in the form of a closely integrated combination of all three disciplines.

But, you say, we have just these ingredients in our undergraduate curriculum. We do, but they are far from making up an integrated unit. Instead, they are more often three separate courses, each of which proceeds on its way with little appreciation either for the new role that engineering has assumed, or even for the close research ties that these three sciences have enjoyed amongst themselves for the past several decades. Their concentration on the details and logic and self-consistency of their own views or courses appears to have sacrificed much of the unified, integrated value that more concerted effort might have developed for the appreciation of nature's laws and for more scientific engineering application. The chemist teaches about the atom in considerable detail, and the physicist also manages to get to the atom. From their different treatment of the subject, however, an engineering student would scarcely find assurance that these atoms are the same one, constituting the stuff that makes up the core of his whole technical life.

I submit, therefore, that the most urgent and important need in our undergraduate engineering curriculum is for a more effective science package, which I hereby propose.

A New Science Package

While the development of the characteristics of this science package should be a project for a whole group of scientists and engineers, I should like to hazard a few suggestions, nevertheless. (The term "package" is applied here to emphasize the unity of objectives, rather than to imply a single course or one type of teacher.)

To begin with, the *material of this "package" should continue to be*

taught by mathematicians, chemists, and physicists, probably still as parallel courses. There would be joint effort, however, to introduce the subjects in such coordination that the three would support each other all through the two years that such a package might require. That is, when mathematical concepts are introduced, they should, whenever possible, seek to fuse into the physics subject then being taught, both to support the physicist and to be supported by his physical concepts. Similarly the chemist should introduce his concepts so as to derive maximum support from, and give maximum support to, the mathematician and physicist.

But these are the mechanical aspects of the package; the meat of the new approach must lie in the substance and particularly in the end objectives. What, then, might be the aims of this science package?

1. To develop, and to demonstrate, the concepts and basic techniques that underlie science and engineering, through the medium of chemistry, mathematics, and physics.
2. To provide the student with the techniques for extension of these concepts into engineering subjects.
3. To imbue the student with the spirit of investigation that will continue into his engineering practice.

These objectives clearly envision the three current science disciplines as handmaidens for the understanding of natural phenomena rather than as ends in themselves.

First, then, there are needed clear statements as to what are the important concepts of natural phenomena. Conservation laws and conversion of energy, so important in mechanical heat, electrical, and chemical systems, could provide one central theme for a broad theoretical and experimental attack from several sides.

The atom, which the physicist has treated as an afterthought even in two-year physics courses, will have to be given a fairly central place. The physicist will want to unfold some of the marvels of atomic structure and at least touch on the quantum theory in order to dispel any notion that physics and mathematics are logical in the usual sense. The chemist would add his concepts and techniques for the forces that govern chemical behavior of atoms and molecules, and try to correlate them with the physicist's forces. Together they would delve into the science of the solid state, the gaseous state, atoms in violent motion, and properties of the liquid state.

Meanwhile the mathematician would struggle to get as rapidly as possible up to the point where he could attempt differential and integral calculus. If he were clever enough, he might be ready to analyze harmonic systems and some of the electron dynamics at just about the time the physicist introduces these subjects. (Let me note in passing that it would be unfortunate for the electrical engineer to attempt the study of electric currents without first having studied the electron in motion.)

After these and other central themes had been developed, and the way suggested for extension of these into engineering application, there would perhaps be time for some of the details and memory work that now crowd these courses. Or, better still, these details could be taken in stride by the engineering courses, along the lines set out by the ASEE Report on Evaluation of Engineering Education.

It is possible that this material

should be extended over more than two years, perhaps including one required course in the junior or senior year to help correlate with engineering techniques. Even with extension into the third year, it is unlikely that the time consumed for this study would exceed the total time now used.

The principal obstacle to undertaking such a program is lack of textbooks directed to these objectives. I am persuaded that there is interest enough to overcome this obstacle; however, I urge that the movement be started.

Engineering and Cultural Courses

One of the objectives proposed for the Science Package was that the student be helped to continue his spirit of investigation into the engineering subjects. Actually there should be pressure applied to carry the whole Science Package approach into the engineering area also. It seems fruitful to do this, particularly as engineering courses are developed to be mathematically analytical rather than prolonged exercises in hardware design. A certain amount of hardware experience is certainly needed to assure that a graduate is not altogether lost on his first job, but his promotion to advanced engineering is likely to be prejudiced if hardware training has been given preference over more basic engineering knowledge.

Under Engineering Sciences, the Report of the ASEE lists (1) Statics, (2) Dynamics, (3) Strength of Materials, (4) Fluid Mechanics, (5) Thermodynamics, (6) Electrical Circuits, Fields and Electronics, (7) Heat Transfer, (8) Engineering Materials, and (9) Physical Metallurgy. It does seem that under these headings a good many new courses could be developed that are basic and common to more than one department.

A word about the so-called cultural or general studies courses. The Interim Report, with many others, has stressed the importance of including more such courses in the curriculum. Their case is fortunately becoming stronger and stronger. There is a suspicion, however, that the efforts have been more fruitful in the direction of increasing total hours devoted to these subjects than in gaining clearer understanding and definition of objectives or of what should be taught under this heading. But time and continued study will resolve these difficulties also.

Research; Its Importance and Hazards

It seems clear, in short, that research-mindedness is the new way of life for many engineers. By the same token, participation in research is becoming more and more necessary on the part of engineering educators. Training for leadership is more a matter of example and the right attitude and inspiration than it is of quantity of detail swallowed, and the demand is increasing for teachers who inspire this spirit of investigation. By and large, this spirit is best felt and promoted by teachers who themselves are also engaged in "frontier pushing" through advanced research; it seems necessary, therefore, that the spirit and practice of research become important in the life of the engineering campus.

Sponsored research entered the college campus on a grand scale during the Second World War, and has continued to grow. The effect of this has been mixed because so many of the technical programs were addressed to very specific objectives which lacked scientific interest. Nevertheless, many

basic research programs were started by these sponsoring agencies. Schools obtained equipment and experience, and had it not been for these sponsored programs it is likely that colleges would have lagged even more seriously behind the advance of engineering practice.

What of the future of research in colleges and of sponsoring groups? Engineering colleges will have to participate much more actively in research than their own budgets will permit. Sponsored research will have to help pay this bill, and also help colleges to attract capable men whose salaries can be divided between the teaching budget and the research budget.

It also seems clear that attention must be focused on the nature of research programs that ought to be entertained for colleges, as well as the method of sponsorship. A cardinal rule should make research a significant and integrated part of the educational program; research that is noncontributing to engineering technology should be avoided or be separated from the teaching faculty. Each man should work only on programs in which he has personal interest, and of course should exercise initiative to develop such programs.

But who, you ask, would support such research? Fortunately the government agencies and foundations support a great many such fundamental programs. But the base of sponsorship should be broadened to include much more industrial support than has been the case thus far. Industry makes heavy demands for graduates of all types, with emphasis on graduates who have been active in research. But there has been less inclination to support the schools and the research programs that make this training possible. A major shift must call for industrial support of research programs at colleges on terms favorable to the educational needs of the schools. That is, the monies cannot be tied with too many strings, nor the programs defined by narrow-minded individuals who seek quick returns to the sponsoring company.

The responsibility for helping industry to understand this need for support, the types of programs to be undertaken, and the proper terms for implementing grants and contracts, must lie with the individual faculty members, with the school administrators, and particularly with the research contract officers. Fortunately the more forward-looking companies have already sensed both the problem and the hazards, and are willing to cooperate.

Summary

In summary, the trend toward blending scientific activities with engineering continues strong. This calls for support both through proper research activities as a normal part of engineering educational activities, and by a dramatic improvement in the fundamental and engineering science background offered to engineering undergraduates. A science package and its objectives have been proposed, in which chemistry, physics, and mathematics play a more integrated and effective role in strengthening the preparation of engineers for their new, more responsible engineering functions in a more complex engineering world.

OPERATION COOPERATION

W. E. HOWLAND

Professor of Sanitary Engineering
Purdue University, Lafayette, Indiana

A condensation of a paper presented at a Panel Discussion on "Improving the Social-humanistic Stem of Engineering Education through Inter-departmental Cooperation," at a meeting of the Indiana-Illinois Section of the ASEE, Notre Dame University, May 21, 1955.

Surely cooperation rather than antagonism is the method and attitude that should be adopted to accomplish the goals of all the stems and branches and vital twigs of engineering education: whole-hearted and informed encouragement and support of one field of instruction by the teachers of another. Cooperation would be easy if we could all agree with the faculty of Yale University that what is most needed now is an intensification of the intellectual life of the campus. As an example of such cooperation, at Purdue we have had for sometime an enterprise called the Inter-Curriculum Colloquium.

The general purpose of the colloquium is simply to exchange ideas across the academic fences between engineering and social sciences or liberal arts. Discussion leaders have ranged from a philosopher of science to a political scientist. Our English Department has stimulated us with its "Books and Coffee" programs, which we attend by the hundreds. Another venture is the Matchette Foundation lectures which are given by distinguished visiting philosophers. The afternoon symposia in most of the engineering schools have crossed academic boundaries at a very high level. We engineers have heard neuro-physiologists and sociologists, as well as experts in information theory and operations research.

It is the vogue now to emphasize the disagreements and paradoxes and inconsistencies of our ideology. Yet to me the agreements, at least among university teachers, are vastly more impressive. Surely we are all using the same logic and essentially the same methods of deductive and inductive reasoning.

The scientist habitually ascribes a degree of error or improbability to his assumptions and hence also to his conclusions, reminding him to be on the outlook for needed correction; the devotees of certitude, on the other hand, express their humility in a different way. Yet all claim to use the same logic.

What Is Beauty, for Example?

Perhaps there is one value upon which disagreements are now impressive, and that is the value of beauty. In science and engineering it still has a clear and conventional meaning. It is order, balance, harmony; unity, coherence and emphasis; recognizable

uniformity of principles among intricate phenomena, splendor of pattern, as in crystal structure and in the equations that describe it, and fitness of form to function as displayed by a Golden Gate Bridge. The disorder that remains, the perplexity of problems still unsolved, only accentuate the beauty of the order that has been discovered and achieved.

Formerly one was taught to believe that beauty in a similar sense was the goal of the artist, and that a like beauty of character was the passion of the preacher. But lately it appears that the typical modern artist, in abandoning his skills and discipline, has gone all out for disharmony, dissonance, incongruity, the abomination of desolation, the terrible mistakes of nature and the monstrosities of disordered imaginations. Theologians like Reinhold Niebuhr, poets like T. S. Eliot, novelists such as Graham Greene and writers like John Steinbeck and Tennessee Williams have chosen to emphasize the dissonance, the violence, the sin and depravity of natural man.

Science Brings Sanity

Undoubtedly this view should be presented to the students as a factual account of an ancient, recurrent, and now again an influential modern trend. To me it represents a masochistic retreat from the reasonableness of the universe in all its complexity—the view that science increasingly reveals and technology is constantly exploiting for the practical service of man. One of the surest modern roads to sanity is work in science and in applied science like engineering!

But note that I am criticizing what I believe to be a modern and momentary trend in art, music, and theology. I do not despair. Our humanistic program may still be magnificent, for we have the powerful tradition of Michelangelo, Mozart, Shakespeare, Dickens, and Mark Twain. We have the reasonableness, in their different ways, of Aquinas, Descartes, Spinoza, Pascal, William Ellery Channing, C. S. Pierce, and A. N. Whitehead to support us now when all but scientific eyes seem to be focused on madness.

Summed up, these are my ideas:

1. Academic cooperation is important for promoting education in the basic, old-fashioned sense.

2. The pace of campus intellectual activities needs to be stepped up.

3. The academic community is dependent upon the philosophers, poets, literary critics for criticism of values and goals of the University, and for helping us to reach agreement upon them.

4. Tradition must be given its proper role. In science we study our tradition; we question, criticize, and correct it, but build upon it. This is progress. In art we stupidly but willfully reject tradition. And this brings chaos.

EDITORIAL STATEMENT

Perhaps to evolve sound JOURNAL policy we need only point to the increasing importance, complexity, and central responsibility of the Society in the decade or so immediately ahead. As never before, engineering education can afford only the best thought on what should be taught for the finest professional education possible. Equally important are the various ways of accomplishing the proper ends once defined, and the means of finding and employing the staff, techniques, and physical facilities required for the task. Teaching and education in this context, of course, imply at once academic research and administration—the other faces of the instructional-educational problem.

With many societies and associations concerned on the one hand with purely technical advances in engineering arts and sciences, and with other professional organizations concentrating on the serious problems of engineering practice, the ASEE stands strategically in a position to link these groups. As the academic focus and contact point, the Society and the JOURNAL can well serve as a correlating and coordinating force, as a means of exchanging ideas among groups, of keeping our thinking up-to-date and advanced.

In practice this probably means that the emphasis of our limited space should be placed primarily on teaching, learning, and all of their implications, including the educational functions (both undergraduate and graduate) of laboratories, research, and industrial experience, problems of adjustment, plus preparation for and development in professional practice.

Thus theoretical or highly technical essays on thermodynamics, mechanics or electrical phenomena might well go to the recognized journals in their respective fields, unless some adaptation or application were evident, either directly to students or as helps for instructors. The criterion for publication, then, would be excellence in or contribution to educational thinking, insight, knowledge, or technique.

In judging this utility, however, the JOURNAL's function of general service to the Society must also be considered. Divisional or Sectional recommendations should be taken seriously, on the ground that so long as space is available the Divisions themselves are in a position to know what is of value to them—especially if they keep in mind the interests of the several thousand members in other divisions.

It appears that fall issues might well concentrate on summaries of papers from the previous annual meeting. Spring issues might emphasize original contributions defining problems for consideration at the forthcoming annual meeting, plus papers from the winter Divisional and Section sessions. Thus articles would be considered equally on a recommended and voluntary basis.

Balance would still have to be maintained geographically, in terms of size or type of institution, and in point of view, even though occasional ideas were expressed which did not represent the majority or universal thought. There should be room in

the JOURNAL for discussion comments, and for differences of opinion leading to profitable sessions at Annual or earlier meetings.

At the moment this balance is heavily affected by the initial emptiness of the manuscript cupboard (for a time it seemed that writing had gone out of fashion in the ASEE, though this is being rapidly rectified), and by the apparently higher productivity of the semi-humanistic groups (including guidance, psychology, and economics) in contrast to the technical branches. This may also reflect the influences of the Evaluation Report and the Social-Humanistic study. The major immediate exception is the Mechanics Division, which has discontinued its own publication, and so is better supplied with contributions (even after deduction of the highly specialized papers) than the other fields.

The answer to balance is, therefore, rounded production of papers designed for publication. Differentiation by authors between what *sounds* well as a talk and what *reads* well in print would be of great help to the JOURNAL, especially in achieving compactness, concentration of ideas, and economy of space. If stylistic assistance is desired in revising or preparing technical papers for the JOURNAL, the English Division has kindly offered the services of its members, on a local or sectional basis, for consultation with prospective authors from the other Divisions of the Society.

A much-neglected consideration of planning ahead in *time* needs to be noted, too. Under the *two-month* minimum production schedule imposed by the Lancaster Press for each issue of the JOURNAL, material should be received by the JOURNAL at least *three months* in advance of the expected publication date if issues are to be available early, as they should be. In the past, Society members have interpreted as weeks what need to be months, and the expected results have followed.

Last-minute brief items can of course be inserted in galley or page proof not later than one month before publication date, but such entries must be clear, complete, and accurate, requiring no correspondence, further approval, or negotiation.

(Immediately, such elementary considerations as sending in manuscripts typed with six inch column width (72 characters per line), double spaced, on one side of the page, and with a carbon copy or two, would be of great help. Content-wise, brief statements of introduction (purpose) and of conclusions (significance or summary) would add greatly to the effectiveness of most manuscripts received.) For the future, it is hoped that a brief style sheet or booklet can be prepared, that some help can be given by the JOURNAL staff in preparing printable illustrations, and that reasonably prompt reactions will be possible to outlines or abstracts of proposed papers if such service is requested by members.

The experimental revisions of type size, style, and format (unfortunately limited somewhat by those economically available at the Press) have had the same intentions—to increase readability and ease of reference for Society members without undue loss of space or content. Considerable economy in printing and cost has been obtained at the same time. If the Society feels them to be desirable, further changes will be explored, as the initial ones by the Publications were,

and the Editorial Committees. Suggestions will be welcome, both as to appropriate content and form, including such matters as the tentative publication schedules set forth below.

With the cooperation of Divisions, Sections, and members, it is hoped that the JOURNAL can continue and perhaps improve its fine record of publishing dignified but significant articles and information in a unique field of steadily increasing interest and importance.

The arrangement of the academic year suggests a variable publication schedule, if that can be met, possibly on the lines suggested below. Does this appeal to Society members?

Reports of Annual Meeting	September 20–30
Papers from Annual Meeting	October 10
Papers, continued	November 1
Papers, concluded	December 1
Original articles, annual meeting forecasts	January 10–15
Yearbook and enrollments	February 1
Original articles, special-topic issues	March 1 April 1 May 1 June 1

MICHIGAN PROGRAMS

The University of Michigan will again hold the two summer programs, the Workshop for College Professors and the Institute on College Administration. Its fourth annual Workshop for College Professors, June 25 to July 13, will include presentations by a special workshop staff, discussions, and projects related to individual member's needs. The Workshop will be followed by an Institute on College Administration, July 16 to 20. Such problems as the administration of the curriculum, personnel and finance will be discussed by resource leaders, with special attention to institutional self-studies and to the human relations factor in personnel administration; also an opportunity will be provided for individuals to study problems or topics of special interest to them. Additional information may be obtained by writing to the Director, Algo D. Henderson, 2442 U. E. S., University of Michigan, Ann Arbor, Michigan.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

JOHN L. ARTLEY, Chairman
Duke University

HAROLD A. FOECKE, Editor
University of Notre Dame

YOU CAN'T DO IT ALL AT ONCE

ROBERT T. HOWE

Professor of Civil Engineering
University of Cincinnati, Cincinnati

How many times have you read of the various characteristics desirable in an engineering educator, and wondered how you could ever live long enough to acquire all of the traits specified?

Or do you find that you have trouble carrying on a research project while teaching a full schedule, taking a graduate course or two, and writing a book in the evening after the children have been tucked into bed?

If you are troubled by these or similar maladies, this writer says: "Relax! You can't do it all at once! Even Rome wasn't built in a day!"

Under the subheading "Evaluation of a Faculty," the final *Report of The Committee on Evaluation of Engineering Education* lists six qualifications which should be used as criteria for selecting new teachers. It would be difficult to set up a more comprehensive set of qualifications—and still more difficult to find a young man interested in becoming an engineering educator who possessed even a majority of these attributes!

But, in the same way, it would be difficult to find a one-year-old child who could speak well, had good table manners, never quarrelled with other children, and amused himself by reading "The Great Books." In other words, a growth process is required. When a man begins teaching at 22 or 25 years of age, he can hardly be a fully developed teacher. Also, it is difficult for anyone to say how his growth will take place, for not even he is fully aware of how his interests will develop.

While no one can tell just how an engineering instructor's growth will take place, his Dean and Department Head certainly have the right to expect that there will *be* growth, and that it will be in directions recognized as desirable in engineering education.

Because an engineering educator must play a dual role as teacher and professional practitioner, growth must be along both these lines. In the writer's opinion, teaching should be given precedence during the earliest years, for bad or dull pedagogical

habits developed during the first few years may never be broken. It is recognized that very few teachers of engineering have ever "darkened the doorway" of a Teachers College, but there are many books available on the learning processes, and the JOURNAL OF ENGINEERING EDUCATION has carried numerous helpful articles on teaching methods. Teaching is, however, a practical as well as a theoretical art—one which must be acquired slowly with liberal applications of patience and conscientious effort.

An age-old maxim is "The teacher must always learn more than his pupils." This is another reason for concentrating on teaching during the first few years, for the young instructor must spend considerable time in study, preparing for each class. In certain fields, this preparation is so difficult that the new teacher may be required to have a doctorate before he is engaged. Regardless of his previous academic preparation, however, considerable thought must still be put into preparing for each classroom period.

Early interest in the professional societies actively concerned with his teaching field is important to the beginning teacher. While it may not be possible for him to attend national meetings during the first few years, he should certainly make every effort to participate in local ones. Almost every professional publication invites discussion of the articles and papers it prints, and the young teacher should gradually make plans to take part in this activity. His early observations may or may not be printed, and may or may not be valid, but the study necessary for the preparation of such discussions is invaluable. A graduate course or two may be carried each year during this early period, but, again, teaching should be given priority in time.

Outside Activities

After two or three years of classroom experience, the young teacher should be in a position to engage in some outside activity. This might be committee work in professional organizations at the local level, independent or sponsored research, or perhaps some elementary consulting. Please note the "or's"—"You can't do it all at once."

Money received from outside activities can be profitably used for travel to national meetings of professional societies, including ASEE. When, through attendance and active participation in the open meetings, one becomes known by various leaders of such organizations, he will be asked to serve on one or more of the responsible society committees. Such service offers invaluable experience of a forward-looking kind.

A word of caution is appropriate concerning consulting work. The final *Report of The Committee on Evaluation of Engineering Education* states: ". . . the belief is widely accepted that an average of one day per week of the individual teacher's time devoted to consulting activities of a high professional character will reflect to the overall advantage of the institution." It will be noted that the emphasis is placed on "high grade," but the young teacher must often be content with less important arrangements. These less important jobs, however, especially those of routine nature, should not be given too much time merely "for the extra money."

As the young educator progresses with his teaching and professional activities, he will eventually find some topic of particular interest to him in

science, engineering, education, or even administration. To satisfy his desire for additional knowledge in this area, he may undertake a research project on his own initiative, or may decide on additional formal study which may or may not lead to a doctorate. This latter tack is one which the young teacher may not think of, but today a very considerable number of engineering faculty members in their "thirties" are returning to school for further study. There are many financial aids available, even for men with families. These include not only special grants for concentrated study, but also teaching and research assistantships which make possible simultaneous gains in apprenticeship time and experience.

As the enginering instructor pursues his quest for knowledge in a particular field of interest, he will eventually become recognized as an authority in that field. Such recognition will probably bring with it more opportunities for consulting work at a constantly higher professional (and remunerative) level. In addition, the research may lead to the writing of a monograph or book.

Human experience indicates that one interested solely in his own personal welfare and "getting ahead" is not likely to achieve true "success." The man who would lead must be willing to go "the second mile." Church and civic activities also need intelligent, dynamic volunteers, and engineers have a point of view which is most helpful to such organizations. But again "You can't do it all at once"; in becoming a teacher, the engineer must not overlook development of himself as a person, and must not neglect his family or his other human relationships. He owes scholarship and living an equal duty.

Just as the rate of physical and mental growth varies from child to child, so the rate of professional growth varies with individuals, but most engineering teachers will be approaching 40 years of age before they achieve professional maturity. Perhaps this is why the George Westinghouse Award for outstanding teaching is awarded to "young" teachers not over 45 years of age, and why so many recipients have been pushing this boundary age.

It would be folly to say that by following a definite formula any one of us could win the Westinghouse Award; if this were so, the Award would lose much of its significance. But whether he wins the Westinghouse Award or not, every young teacher of engineering students can become recognized as an engineering educator of stature if he will (1) decide that this is what he really wants to be, (2) accept every opportunity to grow professionally and personally, and (3) relax, for he can't do it all at once!

COOPER MADE CHAIRMAN

Dr. Albert H. Cooper, a member of the ASEE since 1939, has succeeded Professor Richard F. Shaffer, a member since 1948, as Chairman of the Department of Chemical Engineering at Pratt Institute, Brooklyn, New York. Dr. Cooper has also replaced Dr. Shaffer as the Pratt representative on the Engineering College Research Council.

THE T-SQUARE PAGE

Sponsored by the Division of Engineering Drawing

W. E. STREET, Chairman
I. L. HILL, Vice-Chairman
H. P. SKAMSER, Secretary-Treasurer
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Editor: ALBERT JORGENSEN, University of Pennsylvania

Chairman's Message

WILLIAM E. STREET
Chairman, Division of Engineering Drawing

The activities of the Division are progressing along numerous fronts as indicated by the number and diversity of the committees which are listed together with personnel in this report. The whole-hearted cooperation evidenced by members in accepting assignments and in performing committee tasks is very gratifying.

The Report on Evaluation of Engineering Education, 1952–1955, recognizes our field and defines our objectives in the following paragraph:

"Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful for these purposes is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, and the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work. Though the Engineer may only supervise the preparation of the drawings required to execute his designs, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with graphical communication." Let us not take these responsibilities lightly.

As a Division we are taking them seriously, not only with the Midwinter Meeting in Chicago on January 27–28, but with our 1956 Summer School in Engineering Drawing. This will be held in conjunction with the Annual Meeting of the Society at Iowa State College. We will begin Summer School sessions on Wednesday, June 20, the week before the Annual Meeting. Drawing Division events will then continue through Tuesday, June 26, featuring a joint conference with the English Division, and Wednesday, June 27, a joint conference with the Mathematics Division.

Theme of the School will be the "Evaluation of Engineering Drawing for the Future." This will be carried out by discussions of modern objectives for drawing and engineering geometry, means of correlation with the other sciences, the aspects of graphic science which accord with the ASEE "Evaluation Report on Engineering Education," and the development of creative and imaginative problems for engineering drawing courses.

This should be a banner year for the Engineering Drawing Division. How about setting some new attendance records?

Committees of the Engineering Drawing Division

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POLICY COMMITTEE: C. H. Springer (chairman), T. T. Aakhus, J. J. Gerardi, R. P. Hoelscher, Justus Rising.

ELECTIONS COMMITTEE: I. L. Hill (chairman), C. I. Carlson, M. B. Lagaard.

NOMOGRAPHY COMMITTEE: D. P. Adams (chairman), J. N. Arnold, D. S. Davis, F. H. Heacock, C. H. Kearns Jr., R. A. Kliphardt, A. S. Levens.

COMMITTEE ON DISPLAY OF STUDENT WORK: M. W. Armfeldt (chairman), E. H. Brock, J. S. Dobrovolny, M. McNeary, F. C. Morris, B. F. K. Mullins, E. G. Pare, L. E. Young.

COMMITTEE ON INSTRUMENTS AND MATERIALS: L. R. Schruben (chairman), C. A. Arnbal, F. Binns, M. F. Blade, H. G. Kinner, C. C. Perryman, P. O. Potts, L. M. Sahag, R. R. Worsencroft.

COMMITTEE ON DISPLAY OF INSTRUMENTS: C. A. Arnbal (chairman), R. M. Coleman, A. Jackson, C. A. Newton, J. E. Pearson, N. D. Thomas.

COMMITTEE ON TESTS: F. C. Bragg (chairman), L. O. Johnson, P. E. Machovina, J. M. Russ, H. C. Spencer, H. C. Thompson Jr., E. C. Willey.

COMMITTEE ON REPRODUCTION PROCESSES: S. M. Cleland (chairman), D. P. Dixon, R. L. Paul, D. N. Pierce, G. Rook.

NOMINATING COMMITTEE: C. H. Springer (chairman), F. C. Bragg, J. J. Gerardi, A. P. McDonald, R. T. Northrup.

GARRELTS RECEIVES AWARD

Jewell M. Garrelts, Renwick Professor of Civil Engineering at Columbia University, and a member of the ASEE since 1935, recently received the "Great Teacher Award" of the University's Society for Older Graduates. The Society is composed of Columbia College and School of Engineering alumni who received their degrees at least thirty years ago and have continued to give service to the University. Professor Garrelts received his Master of Science degree at the University in 1933. A noted bridge engineer, he designed the Rainbow Bridge over the Niagara Falls.

COLLEGE NOTES

Dr. Donald F. Othmer, professor and head of the Department of Chemical Engineering at the Polytechnic Institute of Brooklyn and a member of the ASEE since 1937, has been elected a director of the American Institute of Chemical Engineers for a three-year term.

The Automotive Safety Foundation has offered the University of California three fellowships for the graduate study of highway engineering in 1956–57. One, at $3,000, is open to a college instructor in highway transportation engineering who already holds a master's degree. Two fellowships, at $2,000 each, are open to engineering graduates who have had highway engineering experience. Applications will be closed February 15, 1956. Those interested should write immediately to the Institute of Transportation and Traffic Engineering, University of California, Berkeley 4.

Dr. Martin A. Mason, a member of ASEE since 1951 and Dean of George Washington University School of Engineering, has been appointed Chairman of the Committee on Research of the American Society of Civil Engineering. The Committee's functions are to coordinate the research activities of the Society, review research progress, and pass upon expenditures from the Society's research funds.

Purdue University's School of Civil Engineering and Graduate School have announced the availability of approximately twenty-two graduate fellowships for the summer session, June 11 to August 4, 1956. These fellowships carry a stipend of $700 each, and are made possible by a free grant from the Asphalt Institute. The grants are open to Civil Engineering teachers or research personnel who are qualified for the study of, and are interested in, the technology and construction of asphalt and other flexible pavements. Requests for information, and applications, should be addressed to Professor K. B. Woods, Head, School of Civil Engineering, Purdue University, Lafayette, Indiana.

IN THE NEWS

The Brazilian government has recently conferred upon D. B. Steinman, a member of the ASEE since 1910 and an internationally known bridge engineer of New York City, the Marechal Caetano de Faria Medal in recognition of his professional achievements and his engineering contributions to the Republic of Brazil. In 1924–27, Dr. Steinman designed and built the Florianopolis Bridge over the waters of the Atlantic between the island-city of Florianopolis and the mainland of Brazil. This bridge is still a major South American bridge and is the longest eyebar suspension span in the world.

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Carl W. Muhlenbruch, a member of the ASEE since 1943, has been appointed to the Training Committee of Engineers' Council for Professional Development. The Council is currently engaged in developing a plan of recommended professional growth for young engineers. Mr. Muhlenbruch will supervise the program in the Chicago area.

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An annual award of $250 has been established by Henry and Ida Schuman of New York City for an original prize essay in the history of science and its cultural influences. The topic should be broadly interpreted, and papers should be approximately 5000 words in length. This competition is open to undergraduates and graduates in American and Canadian colleges, universities, or institutes of technology. Papers should be sent to the Chairman of the Schuman Prize Committee, Professor C. Gillispie, History Department, Princeton University, Princeton, New Jersey. To be eligible for consideration, papers must be received on or before June 1, 1956.

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At the recent fall meeting of the Middle Atlantic Section of the ASEE held at New York University, on December 3, 1955, the theme was the future course of enginering education. The conference delegates discussed means of incorporating more basic studies, principally in physics and mathematics, into engineering programs. This would require a reduction in the number of courses in the highly specialized sub-divisions of engineering.

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The Operations Research Group of the Case Institute of Technology, Cleveland, Ohio, plans a three day conference February 1, 2, and 3, 1956 to bring together a panel of experts who will present

five case studies, each representing a different type and phase of business. In addition to the formal sessions, small groups will meet with the conference staff to explore the case studies presented by the speakers. Further information can be obtained from the Operations Research Group, Department of Engineering Administration, Case Institute of Technology.

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In cooperation with the California Institute of Technology and the Massachusetts Institute of Technology, the Ramo-Wooldridge Corporation has announced fellowships in Systems Engineering for the academic year 1956–57. The program covers a twelve month period, and will provide the recipient with an opportunity to pursue a broad course of fundamental study as well as an opportunity to associate and work with successful engineers and physicists in the field of Systems Engineering. Any American citizen is eligible whose qualifications will admit him either to the California Institute of Technology or the Massachusetts Institute of Technology Graduate Schools, and who has completed one year of graduate study in mathematics, engineering or science, before the beginning date of the Fellowships. Application forms can be obtained by writing the Ramo-Wooldridge Corporation, the Ramo-Wooldridge Fellowship Committee, 8820 Bellanca Avenue, Los Angeles 45, California.

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E. W. Carlton, professor of structural engineering, Chairman of the Civil Engineering Department, and a member of the ASEE since 1949, will supervise an $11,500 grant recently awarded the University of Missouri School of Mines and Metallurgy by the Missouri State Highway Commission and the U. S. Bureau of Public Roads. The fund will be used to finance a study of the effects of prestressing upon thin concrete pavement slabs.

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The University of Maryland on December 5 and 6 held a two-day research conference dealing with fluid dynamics, especially problems of transition and the origins of turbulence. The purpose of the program was to present, discuss, and appraise recent significant advances in the field of theoretical and experimental research in reducing friction and resistance and thus increasing the range of airplanes and missiles. Papers were contributed by scientists from the National Advisory Committee for Aeronautics, the National Bureau of Standards, and other government agencies, by American and foreign university professors, and by representatives of industry.

TEACHING POSITIONS AVAILABLE

ASSISTANT PROFESSOR OR INSTRUCtor to teach fundamental Electrical Engineering courses in Midwest Engineering College. M.S. degree or teaching experience desirable. Position available January 1, 1956 or later. Good salary for qualified person. JAN-1

ASSOCIATE PROFESSOR POSITION AT midwest university. Ph.D. desirable, M.S. essential, with teaching and professional experience in Civil Engineering. Also Instructor or Assistant Professor, with Ph.D. degree or willing to work toward it; will teach principally undergraduate subjects in two subdivisions of Civil Engineering. JAN-2

ENGINEERING FACULTY OPPORTUnities at midwest college. Chairmanship of the Physics Department, salary open. Also opening for Electrical Engineering Instructor or Assistant Professor in Power Field. Mechanical Engineering Instructor or Assistant Professor in Heat Power and Engineering Mechanics. Instructor or Assistant Professor in Physics. Opportunity for graduate study. Housing available. Appointments to begin September, 1956. JAN-3

INDUSTRIAL ENGINEER NEEDED CApable of organizing and teaching Industrial Engineering on the undergraduate level in a regular Mechanical Engineering degree program. Should be active in teaching and professional organizations. Salary and academic rank depending upon degrees and experience. Location, Ohio. Appointment to begin September, 1956. JAN-4

ENGINEERING DRAWING, MECHANIcal Engineering, Engineering Physics positions open for qualified applicants. Salaries commensurate with industrial. Location, Northeastern section of United States. Long established college with highest professional reputation. Please give qualifications with replies. JAN-5

MECHANICAL AND METALLURGICAL Engineering positions available. Rank and salary in terms of education and experience; effective February or September, 1956. M.S. or Ph.D. required. Send resume with application. JAN-6

PROFESSOR OF HEAT POWER OR Fluid Mechanics, interested in assuming department headship; experienced teacher, doctor's degree preferred. Wanted by eastern metropolitan ECPD-accredited college for September, 1956, or sooner if available. JAN-7

HEAD OF OFFICE EXTENSION SERVices in the Institute of Technology, State College of Washington, Pullman, Washington. Rank of Associate Professor or equivalent, salary for eleven months. Appointment effective July 1, 1956. Additional information may be obtained by writing G. A. Riedesel, Secretary, Committee for Industrial Services, 159 Engr. Lab. Bldg., W. S. C., Pullman, Washington.

INSTRUCTOR OR ASSISTANT PROFESsor in Mechanical Engineering. M.S. degree preferred. Teaching will be in the heat-power field, both lecture and laboratory. Rank and salary will be equated with qualifications. Appointment effective September 1 or before. Apply to Prof. J. W. Bunting, Head, Department of Mechanical Engineering, University of Cincinnati, Cincinnati 21, Ohio.

ASSISTANT PROFESSORS AND INstructors in Electrical and Mechanical Engineering wanted by the College of Engineering, Marquette University, Milwaukee 3, Wisconsin. Salary commensurate with qualifications. M.S. or work toward it desirable. Opportunity for part-time graduate work at state university. Please forward complete details of education, experience, and personal background to respective department chairmen.

HEADSHIP OF INDUSTRIAL ENGIneering department. Requires background of professionally responsible management position in industry or government, plus good record of publications. Research and teaching experience desirable. Age range 35–50; salary open; position to be filled before September, 1956. Write Chairman, Nominating Committee, Industrial Engineering Department, Pennsylvania State University, University Park, Pennsylvania.

NEW MEMBERS OF THE ASEE

The fifty-eight listed below join the 217 previously enrolled in 1955, a total of 275 for the year.

ARMSTRONG, GLENN K., Instructor of Petroleum Refining, Colorado School of Mines, Golden, Colorado. William J. Chapitis, George W. LeMaire.

BARNES, KENNETH, Head of Engineering Department, Southern State College, Magnolia, Ark. Geo. F. Branigan, R. G. Paddock.

BARRY, MERTON R., Instructor of Drawing, University of Wisconsin, Madison 5, Wis. R. R. Worsencroft, F. O. Leidel.

BATES, O. KENNETH, Professor of Mathematics and Head of Department, St. Lawrence University, Canton, N. Y. Preston Wood Smith, W. H. Allison.

BELL, JAMES M., Instructor of Civil Engineering, Colorado School of Mines, Golden, Colo. T. A. Kelly, F. E. Smiley, Jr.

BISHOP, ALBERT B., 3RD, Instructor of Industrial Engineering, Ohio State University, Columbus 14, Ohio. Harry D. Moore, William T. Morris.

BORG, MATTHEW F., Instructor in Civil Engineering, Lehigh University, Bethlehem, Pa. Edgar K. Muhlhausen, M. B. McPherson.

BUXTON, OWEN E., JR., Instructor in Mechanical Engineering, Ohio State University, Columbus 10, Ohio. Paul Bucher, S. M. Marco.

CONARD, GEORGE F., Assistant Professor of Metallurgical Engineering, Lehigh University, Bethlehem, Pa. Edgar K. Muhlhausen, Robt. D. Stout.

DAVIS, ALPHEUS G., Assistant Professor of Mathematics, Clarkson College of Technology, Potsdam, N. Y. William B. Conroy, John M. Perry.

FINDLAY, JAMES E., Assistant Professor of Engineering Drawing, University of Notre Dame, Notre Dame, Ind. H. S. Altman, Lee Daniel.

FRIEDLAENDER, FRITZ J., Assistant Professor of Electrical Engineering, Purdue University, Lafayette, Ind. M. M. Boring, E. M. Sabbagh.

GALBRAITH, R. A. HARVEY, Visiting Lecturer in Electrical Engineering, The Rice Institute, Houston, Tex. J. S. Water, L. B. Ryon.

GEORGE, JOHN M., Instructor of English, Colorado School of Mines, Golden, Colo. William J. Chapitis, George W. LeMaire.

GOULARD, ROBERT J., Instructor of Mechanical Engineering, Purdue University, Lafayette, Ind. Raymond Cohen, D. E. Regenbrecht.

HANSON, ARNOLD E., Dean of Academic Administration, University of Toledo, Toledo, Ohio. Edwin D. Harrison, W. Sherman Smith.

HEWSON, E. WENDELL, Professor of Meteorology, University of Michigan, Ann Arbor, Mich. Ernest F. Brater, Victor L. Streeter.

HOTCHKISS, JOHN G., District Engineer and Secretary Committee for Education, American Institute of Steel Construction, Inc., New York 17, N. Y. Robert W. VanHouten, William Hazell.

HRABA, JOHN B., Associate Professor of Electrical Engineering, University of New Hampshire, Durham, New Hampshire. Edward K. Donovan, E. H. Stolworthy.

HOFFEE, HARRY L., Assistant Professor of Electrical Engineering, Ohio University, Athens, Ohio. E. J. Taylor, R. C. Quisenbery.

HUNTERMAN, HENRY JOHN, JR., Instructor of Civil Engineering, Colorado School of Mines, Golden, Colo. L. J. Parkinson, William J. Chapitis.

INGERSOLL, ALFRED C., Assistant Professor of Civil Engineering, California Institute of Technology, Pasadena, Cal. Jack E. McKee, D. E. Hudson.

JENSEN, DEAN ELWOOD, Instructor of Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. R. R. Worsencroft, F. O. Leidel.

JURAN, J. M., Consulting Management Engineer, Tuckahoe, N. Y. Norman N. Barish, David B. Porter.

KEIGHTLEY, WILLARD O., Acting Chairman of Civil Engineering, Lawrence Institute of Technology, Detroit, Mich. M. M. Ryan, H. G. Erneman.

KEMPER, ARTHUR B., Head of Chemistry Department, Manhattan College, New York, N. Y. Brother Joseph McCabe, Brother B. Austin Barry.

KING, RENO C., Associate Professor of Mechanical Engineering, New York University, New York, N. Y. Fred Landis, A. H. Church.

KRAJOVIC, JESSE J., Manager College Relations Department, The Glenn L. Martin Company, Baltimore, Maryland. John M. Hollyday, A. Lawrence Guess.

LADD, CHARLES F., Supervisor, Personnel, Industrial Relations Department, American Steel & Wire Division of U. S. Steel Corporation, Rockefeller Building, Cleveland 13, Ohio. Max B. Robinson, Robert B. Auld.

LATHAM, ROBERT F., Instructor of Marine Engineering, U. S. Naval Academy, Annapolis, Maryland. George W. Slaughter, Arthur E. Bock.

LEROY, LESLIE W., Professor and Head of Department of Geology, Colorado School of Mines, Golden, Colo. R. J. Parkinson, William J. Chapitis.

LEWIS, ROBERT M., United States Steel Corporation, Fairless Works, Fairless Hills, Pa. John L. Neal, Jr., Cecil A. Kapp.

LINN, MAX K., Supervisor of Case Costs and Personnel Division, Sandia Corporation, Albuquerque, New Mexico. Thos. Farrell, Jr., J. W. Howe.

MARKS, JAMES A., Instructor of Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. R. R. Worsencroft, T. O. Leidel.

MATHIAS, ROBERT A., Assistant Professor of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. Edward R. Schatz, Gaylord N. Penney.

MENIUS, DR. A. C., JR., Professor of Physics and Assistant to Dean of Engineering, North Carolina State College, Raleigh, N. Car. J. Harold Lampe, John W. Cell.

MONSEES, MELFORD E., Chief, Program Development Branch, Supervisory Civil Engineer, Corps of Engineers, Kansas City District, Kansas City, Mo. H. O. Croft, Adrian Pauw.

MORGAN, MOSES J., Assistant Professor and Assistant Agricultural Engineer, State College of Washington, Pullman, Wash. J. Roberts, Max C. Jensen.

MOSS, HARLAND R., Associate Professor of Chemistry, Loyola University of Los Angeles, Los Angeles, Cal. Daniel E. Whelan, Jr., Allen R. Joyce.

OSTLE, BERNARD, Professor of Mathematics, Montana State College, Bozeman, Mont. E. W. Schilling, John W. Hurst.

PIERCE, DONALD FREDEMON, Instructor of Science, General Motors Institute, Flint, Mich. Joseph M. Biedenbach, Paul W. Stout.

PINCKNEY, DALE E., Assistant Professor of Humanities and Social Studies, Montana School of Mines, Butte, Montana. A. E. Adami, W. Clifford Laity.

RENDA, MUAMMER FAIK, Instructor in Mechanical Engineering, Purdue University, Lafayette, Ind. Raymond Cohen, D. E. Hegenbrecht.

RIEGEL, MALCOLM S., Training Coordinator (Personnel), New York Central Railroad, New York, N. Y. G. W. Bergren, O. W. Witzell.

RODGERS, PAUL A., Assistant Professor of Geophysics, Colorado School of Mines, Golden, Colo. T. H. Kuhn, William J. Chapitis.

ROMEO, ALBERT, Instructor of Engineering Drawing, Ohio State University, Columbus, Ohio. Ralph S. Paffenbarger, Chas. D. Cooper.

ROSS, RICHARD A., Instructor of English and Social Science, Franklin Technical Institute, Boston, Mass. Leo R. Dantona, B. K. Thorogood.

SCHIFFMAN, ROBERT L., Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. Edgar K. Muhlhausen, Cyril D. Jensen.

SMITH, CHARLES O., Staff Member, Oak Ridge School of Reactor Technology, Oak Ridge, Tenn. Donald G. Downing, Albert J. Schwieger.

STRODE, WILLARD, Associate Professor of Architectural Engineering, University of Kansas, Lawrence, Kan. Geo. M. Beal, Donald L. Dean.

THORN, DONALD C., Lecturer, Electrical Engineering, University of Texas, Austin, Tex. R. W. Warner, B. N. Gafford.

TUCKER, WALTER H., Director of Engineering Extension, Alabama Polytechnic Institute, Auburn, Ala. Joshua E. Hannum, Earl D. Brown II.

UNGAR, ERIC E., Instructor of Mechanical Engineering, New York University, New York, N. Y. Austin H. Church, F. H. Posser.

WARD, JAMES B., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. Henrich J. Oorthuys, Harry W. Hale.

WEBB, BRYAN, JR., Assistant Professor of Electrical Engineering, University of

Arkansas, Fayetteville, Ark. G. Newton H. Barnette, Geo. T. Branigan.

WIERZBICKI, LAWRENCE J., Instructor of Engineering, Loyola University of Los Angeles. Daniel E. Whelan, Jr., John E. Sokoly.

WILCOX, VIRGINIA L., Acting Librarian, Library of Colorado School of Mines, Golden, Colo. L. J. Parkinson, William J. Chapitis.

YOUNG, DONALD F., Instructor of Theoretical and Applied Mechanics, Iowa State College, Ames, Iowa. S. J. Chamberlin, Glenn Murphy.

58 new members
217 previously added

275 new members this year

TECHNICAL INSTITUTE BULLETINS

At the November meeting of the ASEE General Council, the need for a list of accredited Technical Institutes and their programs was expressed. It was felt that perhaps college administrators, department heads, and members in general might be unaware of the two publications already available to fill this need, and that additional JOURNAL notice was therefore desirable.

Technical Institute Programs in the United States Accredited by ECPD is issued annually by the Engineers' Council for Professional Development, 29 West 39th Street, New York 18, New York, at 25¢ per copy, about 20 pages. Listed are objectives and procedures for accreditation, accredited programs of the technical institute type (one to three years beyond secondary school), and personnel of regional committees in the technical institute accrediting program.

Our own ASEE Technical Institute Division, in cooperation with the ECPD and the National Council of Technical Schools, has prepared *The Engineering Technician* as a guidance publication. About 16 pages, 25¢ per copy, it can be obtained from the national headquarters, ASEE, Urbana, Illinois. Contents include discussion of the engineering and production team, the engineer, the engineering technician, and the skilled craftsman, educational programs for the engineering technician, and areas of employment.

At the professional level, ECPD also compiles and distributes, at 25¢, *Accredited Curricula Leading to First Degrees in Engineering in the United States and Canada*, as well as its *Annual Report* at $1.00 each. Both are available from ECPD Headquarters.

MEETING OF THE EXECUTIVE BOARD

November 13, 1955

A meeting of the Executive Board of The American Society for Engineering Education was held in Room 116 of Kellogg Center at Michigan State University on November 13, 1955. Those present were: M. M. Boring, President; F. C. Lindvall, L. J. Lassalle, W. T. Alexander, and H. K. Work, Vice Presidents; G. W. Farnham, Treasurer; W. Leighton Collins, Secretary; E. C. McClintock as Editor, and P. N. Powers, guest. President Boring presided.

The minutes of the Executive Board are not printed in complete form to avoid duplicate reporting on actions involving both Executive Board and General Council discussions. Pertinent actions of the Board not referred to in the General Council Minutes are:

1. The Westinghouse Educational Foundation did not approve an expense item of $1,000 for holding a meeting of the Westinghouse Award Committee at which the award winner is to be selected. The Executive Board VOTED not to allocate funds for holding such a meeting and that the committee be so informed.

2. The Executive Board VOTED to approve Hofstra College as an Affiliate institutional member.

3. The Secretary requested each member of the Board to consider adaptation of "Industry's Stake in ASEE" to educational institutions, instead of the previously circulated draft, and submit comments to him.

4. *Division Publications and Division Dues.* The Secretary reported on the increased desire for divisional publications, the increasing difficulties in financing their printing, and the proposal of one division to adopt a $2.00 divisional membership fee. It was agreed that payment of divisional dues could not be a requirement for Society membership nor a requirement for attendance at any meetings of the Society or of any of its Divisions. It was also agreed that divisional or committee publications must not interfere or compete with the JOURNAL OF ENGINEERING EDUCATION. The Executive Board VOTED that the Secretary request all Division Chairmen to send information on divisional publications and their financing to Vice President Lassalle, who would refer a tabulation of the replies to the Publications Committee for recommendations.

5. The Executive Board agreed the Secretary should make a study of the Yearbook Information Card, seeking advice from appropriate sources.

6. The suggestion that a joint committee with the Association of General Contractors be appointed was discussed. It was agreed not to appoint such a committee but that if the Civil Engineering or Relations with Industry Divisions desired liaison they should establish it.

Respectfully submitted,

W. LEIGHTON COLLINS, *Secretary*

MINUTES OF THE GENERAL COUNCIL MEETING

Michigan State University, East Lansing, Michigan

November 14, 1955

A dinner meeting of the General Council of The American Society for Engineering Education was held in the Galaxy Room of Kellogg Center on November 14, 1955, at 6 P.M., President M. M. Boring presiding. Those present were:

George W. Farnham, F. C. Lindvall, James H. Sams, W. T. Alexander, E. T. Donovan, Norman A. Parker, Paul Weber, K. L. Holderman, Ralph A. Morgen, L. F. Eisenberg, P. E. Soneson, Leo. Jos. Lassalle, M. A. Durland, G. F. Branigan, David J. Peery, Donald G. Stillman, W. Irwin Short, M. R. Lohmann, H. K. Justice, Rex Schoonover, C. A. Brown, William Hazell, N. W. Dougherty, L. E. Grinter, W. R. Woolrich, H. K. Work, G. C. Godbey, M. M. Boring, W. L. Collins, A. R. Hellwarth, Harold Flinsch, E. C. McClintock, Mrs. Naomi Garman.

1. *Correction to minutes of June 20 and 22, 1955.* Item 11g, p. 6. The General Council VOTED to substitute the following paragraph, the italicized portions being new:

"C. S. Jones, Chairman of the Division, presented the need for a book *on Technical Institute Education* telling *of the nature* of the work of the Technical Institute and the place of its graduates in industry. *This Division of the Society for some time past has been greatly interested in this and has endorsed the proposal and has officially approved the personnel of the committee as selected.* A. L. Williston wishes to make an initial gift to the Society of securities, valued at $6,000, but to be sold by the Society for defraying expenses involved in preparing *this* book, that the Society administer the funds in a manner similar to that followed for other projects, and that the copyright be in the name of the Society. The Council VOTED to approve the appointment of this Committee, *as a Committee of the Society,* by the President, to accept the securities presented for conversion into cash, and that the Committee be reimbursed for its expenses in accordance with the established practice of the Society."

2. *Report of the Secretary.* The list of subscriptions to the JOURNAL OF ENGINEERING EDUCATION has been studied to improve the bookkeeping and billing procedures. It was agreed that the 150 (approximately one-fourth of the total) which are in an indeterminate status should be discontinued if another letter brings no results.

The Constitution of the Society provides for the dropping of members when they are two years in arrears in dues payments. Prior to being dropped the member must be "notified." The Executive Board authorized the Secretary to interpret the return of first class mail containing the notice of the proposed dropping as "notification."

Preparing the Yearbook has been a tremendous task because of the enormous number of changes. It is hoped errors will be at a minimum but some are bound to creep in. The help of all in informing the Secretary's office of corrections is solicited.

The Executive Board approved a procedure for soliciting funds and a copy will be sent to all Division and Section Chairmen. The procedure also is attached to these minutes as Appendix A.

The yearly dues of the Society for ECPD and EJC memberships have increased; the former from $500 to $600, and the latter from $473 to $945.69. The great increase of the latter results primarily from plans to employ an assistant secretary, additional stenographic help, and rental for more office space. The amount of each assessment is a percentage of the total budget based on the dues income of the Society.

The budgets of Divisions and Committees have been increasing rapidly and now total almost $2000. In the near future these budgets, the problems of divisional publications, and of divisional dues will have to undergo a thorough study.

3. *Report of the Treasurer*

(a) The report for the first quarter of the fiscal year was briefly reviewed. Expenditures were normal. In accordance with the recommendations of the Auditor, this and future quarterly statements will contain only items chargeable to the current fiscal year. However, to enable comparisons to be made with previous statements, the former practice of including all items will be continued (in a separate column) in this year's reports.

(b) $7500. in U. S. Government bonds became due and this amount was deposited in a Boston savings bank in order to earn 3% interest. The savings accounts of the Society will all be placed in Eastern banks which are currently paying 3% interest.

(c) The Annual Audit was briefly discussed. The Society operated at a profit of about $2200 for the year, despite the unanticipated expenses of moving the Society's office from Evanston to Urbana. At the suggestion of the Auditor some changes in the bookkeeping procedures were made. The complete audit was printed on page 397 of the December, 1955, *Journal.*

(d) The Pennsylvania State University has just submitted its final report on the 1955 Annual Meeting and has turned over to the Society a check for $767.88, the excess of receipts over direct expenditures.

4. *Reports of the Vice Presidents*

(a) F. C. Lindvall, regional and sectional affairs. All Sections have now determined the dates for their meetings. A plea was made for closer relationships between the affairs of the Sections and the affairs of other units of the Society, particularly in programming (where the many aspects of the report on Evaluation of Engineering Education must be extensively discussed), in cooperating closely with the Relations with Industry Division in establishing grass-roots programs with industry, in discussing the problem of loss of faculty to industry, and in submitting more papers presented at Section meetings for publication in the *Journal.* At the request of the Physics Division, each Section is requested to appoint a liaison representative to the Physics Division.

(b) L. J. Lassalle, divisional and subject matter affairs. Almost all committees are appointed, a list of the chairmen having been published in the October issue of the *Journal.* A letter is being sent to all Division chairmen presenting suggestions for the Annual Meeting programs and

requesting as many joint meetings as possible.

(c) W. T. Alexander, ECAC. Highlights of ECAC committee work are the completion of the reading list for prospective engineering students, the continued progress on placement tests, and the recognition of the need for increased activity in coordinating the work of secondary schools with the report on Evaluation of Engineering Education.

(d) H. K. Work, ECRC. The Review of Current Research is completed and copies can be purchased for $2.00 each from the ECRC secretary. The book on creativity in engineering needs additional work before it will be acceptable for publication. Plans for the award for outstanding research are progressing and the first award will be made in 1956. The budget of $40,000 for the study of the Research Needs of the Engineering Sciences has been approved by the Executive Board, the plans perfected, and funds from a foundation are being sought.

5. *Report of the Editor.* The Executive Board has authorized the Editor to work with the Publications Committee on changes in the *Journal.* It is intended that in addition to containing high grade papers the *Journal* can be used more extensively to inform members of the activities of the Society, the work of its various units, and the programs of organizations with which it is affiliated. Papers presented at section meetings are the property of the Society and the good papers presented at section meetings should be forwarded to the Editor for publication in the *Journal.* A request for suggestions to improve the *Journal* was made.

6. *Industrial Fellowships Committee.* R. A. Morgen, Chairman, reviewed the proposed program, stating that the committee believed acceptance was desirable because the plan makes available a new source of funds (small companies not able to carry out a program of their own) and because all qualified institutions have an equal chance to receive the fellowships. Copies of a letter from The Leeds and Northrup Foundation stating the proposal (Appendix B) and a copy of "Interim Rules for Industrial Fellowships Administered by The American Society for Engineering Education" (Appendix C) were distributed to all present. The Secretary reported he had consulted the member of the College of Law at the University of Illinois who is an authority on non-profit corporations in the State of Illinois; based on a reading of the objectives of the Society and other pertinent sections of the Constitution that authority was of the opinion that there was no legal problem. The General Council VOTED to approve the plan as presented by the committee except that the number of doctorate degrees granted by an institution between January 1950 and June 1951, inclusive, be three instead of five. In the discussion it was pointed out that this was a "trial run" and that there was no intention of extending the program to include scholarships.

7. *Report of the Committee on Degree Designations.* J. H. Sams, Chairman, presented the statistics obtained by the committee, on which the committee report (first presented at the June 1955 meeting and attached as Appendix D) was based. After considerable discussion, the General Council VOTED to approve the report and request the committee to

continue its study of the five-year first degree and two-year undergraduate programs.

8. *Study of Educational Requirements for Engineers in the Nuclear Industry.* In the absence of P. N. Powers, Chairman of the Atomic Energy Education Committee, the Secretary briefly reviewed the proposal, approved at the June meeting, stating that the budget had been revised. He also reported that at its November 13 meeting the Executive Board voted to approve the budget of $26,100, the money to be raised from industry in the name of the Society and to delegate the responsibility for utilization of the funds to Purdue University provided there is a periodic reporting to the Secretary and providing there is no legal objection to the procedure.

9. *Summer Institute for Engineering Faculty.* In the absence of P. N. Powers, Chairman of the Atomic Energy Education Committee, the Secretary briefly presented the proposal, a copy of which had been mailed to all members of the Council. To facilitate approval of the project, the Executive Board at its November 13 meeting had studied the proposal and voted to recommend to the General Council approval of the plan in principle, as well as the budget of $47,775 provided the General Council accepts the plan. A letter of transmittal dated Nov. 13, 1955 (Appendix E) and excerpts of another letter containing the budget (Appendix F) were read. The General Council VOTED to approve the proposal.

10. *Survey of the Teaching of English in Engineering Schools.* C. A. Brown, representative of the English Division, submitted the proposal, which had been sent to all members of the Council. It was brought out that this study followed logically from the report on Evaluation of Engineering Education and covered an area not included in the Humanistic-Social study. The President stated that the Executive Board had discussed the report at its meeting on Nov. 13 and after considerable discussion voted to recommend to the General Council a deferment of the study until after the final report of the Humanistic-Social Research Project is published and until after the financing of other current projects has been completed. The Executive Board believed the English Division also might wish to consider an evaluation of the engineering student's ability and the relationship of ability (or achievement) to secondary school preparation. The General Council VOTED to defer action on the study, making it very clear the project was not disapproved and could be resubmitted at any future meeting.

11. *Summer School for YETS.* President M. M. Boring explained the changes in the plans for the Summer School. Fifty outstanding YETS selected by their schools are to be employed by industries for the summer, but would be released for four weeks to attend the Summer School. Salary, travel, room and board for those attending the Summer School are to be paid for by the industries; the individual's university is expected to pay the cost of transportation to and from the job location. The Society thus does not need to solicit funds. The estimated cost to industry for 50 YETS attending a four week course is:

Food and lodging	$7,600
Instruction cost	5,000
Service, supplies	600
Stipend to attendees	$25,000
Total	$38,200

The Executive Board reviewed the plan and the budget because of its previous instructions to President Boring to proceed with the development of a program and because the General Council at its meeting on June 20 and 24, 1955 had authorized implementation of the Summer School. The Executive Board voted to recommend the plan to the General Council for approval. The General Council VOTED to approve the plan outlined above.

12. *Summer Institute on Mathematics in Engineering.* F. C. Lindvall, Chairman of the Committee, reported that the closed conference for about 25 will be held at the California Institute of Technology on Nov. 28, 29, and 30, 1955. The open conference will be held at the University of Michigan on June 20, 21, and 22, 1956. The general approach is to determine the mathematical background for engineering as required today, and what it should be for *all aspects* of an engineer's education as it can be envisaged for the future.

13. *Annual Meeting*

(a) The President reported that the Executive Board voted to have two dinner meetings at Iowa State, one on Sunday, June 24, and the other on Wednesday, June 27.

(b) The President reported that the Executive Board recommends the General Council have two meetings at Iowa State, a dinner meeting on Monday, June 25 and a luncheon meeting on Friday, June 29. The latter is a change from a breakfast meeting which has seriously conflicted with the ECAC meeting of institutional representatives; because many members have been expected to attend both meetings, each has been poorly attended. The General Council VOTED that its meetings at Iowa State be a dinner meeting on Monday, June 25, and a luncheon meeting on Friday, June 29.

(c) The Secretary reported that Iowa State has completed its committee organization for the Annual Meeting, that the committee is meeting regularly and sending a copy of its minutes to the President and Secretary, that a preliminary budget has been received, and that Senator B. B. Hickenlooper has accepted the invitation to speak at the Annual Banquet on the subject "Peacetime Uses of Atomic Energy."

(d) The President reported that the 1957 Annual Meeting at Cornell University would be a joint meeting with the American Association of Physics Teachers, provided their Board gives formal approval; that an invitation has been received to have the 1958 Annual Meeting at the University of California at Berkeley; and that the 1959 Annual Meeting would be held at Purdue University on June 22–26. Then General Council VOTED to accept the invitation of the University of California to meet at Berkeley in June, 1958.

14. *Humanistic-Social Research Project.* The President reported that as a result of the request from the Chairman of the project, the Executive Board voted to handle the report in a manner similar to that for the Evaluation of Engineering Education report, to print 10,000 copies, to have the final report submitted to the General Council for approval at its June 1956 meeting, to provide free copies to those attending the Annual Meeting at Iowa State College, and to thereafter sell copies at 25¢ each, 20¢ each in lots of 50 to 100, and 15¢ each in lots of 100 or more, if these prices were consistent with the

cost of printing. There were no objections to this plan, except that it was agreed the report be submitted to the General Council at its meeting on Monday, June 25.

15. *Graduate Study Project.* The President reported the Executive Board approved the budget of $15,000 at its September meeting and that steps were being taken to secure the funds.

16. *Selection, by Sections, of YET sub-chairmen to Serve on the National YET Committee.* The report of last year's YET Committee recommended that instead of the Chairman of the National Committee appointing a sub-chairman for each Section it would be much better for each Section to elect or appoint its sub-chairman, most probably at the time of its meeting. The General Council VOTED that starting with the year 1956–57, each Section select its own YET sub-chairman, informing the Secretary of the selection as soon as possible after July 1 each year.

17. *Difficulty of Employing Teachers to Meet Future Increases in Enrollment.* This common problem was discussed from a number of points of view—employment of retired personnel from universities as well as from industry, responsibilities of industry, use of part-time instructors, and how to get graduates to enter the teaching profession. It was agreed that the questionnaire to be sent out by the Relations With Industry Division to all deans should ask about the availability of retired personnel, their area of teaching, and whether the institution would be willing to employ such people. The compiled replies will be made available to the deans.

18. *List of Technical Institutes and Their Programs.* N. A. Parker presented the need for such information and stated that after much searching the booklets "Technical Institute Programs in the United States Accredited by ECPD" and "The Engineering Technician," published by the Technical Institute Division of ASEE, were the most helpful. It was agreed that these booklets be publicized in the *Journal.*

19. *Joint Committee with the Association of General Contractors of America, Inc.* The General Council agreed with the thinking of the Executive Board that if the Civil Engineering or Relations With Industry Division desired liaison they should establish it.

20. *Aid in Making Movies to Interest High School Students in Engineering and Science.* The Secretary reported a Hollywood studio was planning to make a series of such movies and requested information about the extent of help the Society might give. There was no indication that the Society should participate in such a venture.

21. *Spring Meeting of the Executive Board.* The President announced the Executive Board had voted to have its Spring meeting on April 27, 1956, at the University of Denver; this is the time of the Rocky Mountain Section meeting.

22. *Other Business*

(a) *Report on Meeting of National Commission for UNESCO.* H. K. Justice, who represented ASEE at the November 3–5 meeting of the Commission at Cincinnati, reported that the Commission is an agent of the United Nations and has as its purpose contributions to world peace and security. Much good work has been done in aiding foreign libraries and museums, opening free libraries, de-

veloping a program for arid zones, and establishing a European organization for nuclear research. However, he was unable to determine any way in which ASEE could aid unless UNESCO developed programs of specific interest to the Society or to the International Relations Committee of ECAC.

(b) *Report from Relations With Industry Division.* A. R. Hellwarth, representative of the Relations with Industry Division, reported that the Division is preparing a constitution; that they are interested in and want the help of Sections in stimulating grass-roots interest in RWI activities even though some areas incompatible with section boundaries are desirous of instituting local programs; that a sub-committee with A. R. Hellwarth as chairman would like to make a survey of the colleges of engineering regarding loss of staff to industry and the success of colleges in interesting graduates in teaching careers. The General Council VOTED to approve the making of a survey by the Relations With Industry Division of colleges of engineering to determine the extent of losses of staff to industry and the success of efforts to interest graduates in teaching careers.

(c) *Report of Committee on Follow-Up of the Report on Evaluation of Engineering Education.* President M. M. Boring reported the committee under the chairmanship of W. L. Everitt had met all day and submitted a request for the appointment of a number of committees. The General Council VOTED that the President appoint the following committees:

(1) A committee to study the methods and philosophy of teaching and developing the creative ability in students through work in engineering analysis and design. The purpose of the study will be to define the unique characteristics of engineering analysis and of engineering design and to define the philosophy and techniques of teaching, giving particular attention to their interrelations and methods common to various professional areas as well as the various necessary technological backgrounds.

(2) Six committees, one for each of the engineering sciences listed in the report on Evaluation of Engineering Education, to make a study of the respective areas. The purpose is to define the area, the philosophy of subject development, techniques of teaching (including laboratories), and to recommend a forward-looking plan for each of the sciences involved, giving particular attention to their interrelations and their integration into engineering curricula.

(d) *Fall Meeting.* The President reported that the Executive Board requests the General Council to concur with the decision of the Executive Board to meet with ECPD in October, 1956, the Executive Board having a 6:00 P.M. dinner meeting on Friday, October 26, and the General Council to have a 7:30 A.M. breakfast meeting on Saturday, October 27. The General Council VOTED to concur with the Executive Board action.

The meeting adjourned at 10:30 P.M.

Respectfully submitted,
W. LEIGHTON COLLINS, *Secretary*

Appendix A—American Society for Engineering Education—Procedure for Securing Funds from Foundations, Industry, and Other Sources

The following procedure shall be followed in all fund raising efforts of the American Society for Engineering Education:

1. All funds are to be raised in the name of the Society.

2. All plans for the raising of funds must be submitted to the Executive Board for their critical examination and approval before any attempt is made to solicit funds; an itemized budget is to be submitted.

3. A member of the Executive Board shall be intimately associated with the presentation of a request or actually do the presenting himself.

4. The accountability for all funds shall be in the hands of the Secretary. This does not preclude the advance of money to program directors or committee chairmen to take care of miscellaneous expenditures for which they will be accountable to the Secretary.

5. The plans submitted to the Executive Board must indicate a continuity of organization and responsibility for the completion of the project by competent individuals.

6. Funds raised are to be adequate to pay for the cost of printing the number of reports deemed adequate to achieve the objectives of the project.

7. The income from the sale of reprints shall revert to the general funds of the Society.

8. Any money remaining after the completion of the project shall be disposed of as directed by the Executive Board.

9. Any departure from these procedures shall have the approval of the Executive Board.

Appendix B—Excerpts from Leeds and Northrup Foundation Letter from I. Melville Stein, Chairman, to W. L. Everitt, ASEE Vice President, June 16, 1955

In recognition of the need for increasing the number of fully trained graduates in engineering and for the support of fundamental research in institutions of higher learning, we desire to support, through the Leeds & Northrup Foundation, graduate study and research in those fields of engineering on which the Leeds & Northrup Company activities are most dependent. Following discussions with you and very helpful suggestions from Dr. Ralph Morgen, I understand that ASEE is willing to undertake the administration of such a program of scholarships and, accordingly, the Leeds & Northrup Foundation desires to commit itself as follows:

We agreed to commit ourselves to the support of a three-year scholarship covering graduate work in engineering leading to a doctorate in engineering, at a total cost of $9000, payable in three annual installments of $3000 each. It is our intention to start such a new scholarship each year, so that by the third year there would be three running concurrently. While this is our intention, it is our feeling that until the support of such graduate study is more fully funded in our Foundation, the program of

starting a new three-year graduate scholarship each year should be an expression of intent rather than a commitment. Accordingly, the present commitment is for a single scholarship at a total cost of $9000, payable as indicated above.

Our present feeling is that these scholarships should be rotated in the fields of electrical, mechanical, and chemical engineering, but not on a rigorous basis because the availability of suitable candidates might make it desirable to depart at times from any systematic rotation in these three disciplines. The selection of both the student and the school would be left entirely in the hands of ASEE.

Appendix C—Interim Rules for Industrial Fellowships Administered by ASEE

I. Purpose

(a) It is recognized that there is need for fellowships to assist graduate students to receive advanced degrees in the various disciplines and to assist the institution in supplying this education to the students. It is further recognized that a considerable number of industrial organizations is aware of this need but that there is a lack of mechanism for distribution of these funds.

It is, therefore, the purpose of this program to make companies aware of the need for research support and the support of graduate students in the various engineering disciplines and to assist the companies in distributing the funds to appropriate institutions in accordance with their wishes.

II. Specific Case

One donation of a grant of $3000 a year for a period of three years has been made to ASEE this year by the Leeds and Northrup Foundation. A copy of the grant document to the Society is attached.

ASEE has decided to accept this generous offer by the Leeds and Northrup Foundation as a test case to explore the possibilities of using this mechanism for the support of further research in the member institutions of ASEE which are eligible in accordance with the donor's request. If this exploratory program proves successful, it is anticipated that additional funds will be sought. In each case, the institution and the graduate student will be aware of the identity of the sponsor. This particular grant will be known as ASEE-Leeds and Northrup Foundation Grant No. 1.

III. Interim Rules for the Academic Year 1955-56

(See "Announcement of ASEE Industrial Fellowships.")

Appendix D—Report of the Committee on Degree Designations

The committee on Degree Designations has considered the resolution of the Technical Institute Division and the further requests from Council and makes the following recommendations:

2 Year and 3 Year Programs—These are Junior College and Technical Institute programs with a minimum of 60 semester hours in two academic years. We recommend the Associate degree in the appropriate field, such

as: Applied Science, Technology, Science, Drafting, or Aircraft Maintenance.

4 Year Baccalaureate and 5 Year Cooperative Programs—These are the most widely offered programs at the present time and lead to a bachelor's degree. We recommend Bachelor of Science in the appropriate field, such as B.S. in C.E.

5 Year First Degree Program—No decision has been reached. It is recommended that this matter be referred to this committee for further study.

Master of Science—A program normally achievable in one year or more above the bachelor's level. We recommend the Master of Science in the appropriate field, such as M.S. in C.E.

Doctoral Program—A program above the master's level requiring additional study and proof of research ability. We recommend the continuance of the present practice of awarding the Ph.D. or Sc.D. for this program. Since the Doctor's degree is often awarded as an honorary degree, it is recommended that some other designation than either of the above be used for honorary purposes and that the abbreviation (Hon.) in parenthesis be shown after such degrees, such as Doctor of Engineering Sciences (Hon.) or Eng'g Sc.D. (Hon.).

Professional Degree—The survey of present practice among engineering colleges shows that the majority of the colleges no longer award this degree. Sixty-one colleges now offer the degree, most of them requiring at least five years of engineering practice after graduation and the submission of a satisfactory thesis. The committee is in favor of discontinuance of this degree as now given.

Respectfully submitted,

S. C. Hollister
K. L. Holderman
Harold P. Rodes
Leo F. Smith
J. F. Downie Smith
H. K. Justice
James H. Sams, *Chairman*

Appendix E—Report to the Executive Board of the ASEE on a Proposed ASEE Institute on Atomic Energy

Late in the summer representatives of Argonne, the AEC, the National Science Foundation, and Northwestern University invited me to consider with the ASEE Committee on Atomic Energy Education possible sponsorship by ASEE of a Nuclear Energy Institute. As a result, the matter was brought before the Committee and examined in detail. It is the unanimous opinion of the Committee that ASEE should sponsor this Institute as a means of helping to alleviate the shortage of engineers with training in the nuclear field.

The specific plan which we have developed is described in the attached materials, including drafts of letters to be sent from ASEE to the National Science Foundation, the Atomic Energy Commission, and Northwestern University.

The details have been worked out by a subcommittee under the chair-

manship of Dean George Hawkins which will, in addition, have the following responsibilities:

1. To advise and assist Dean Loughridge in his administration of the program as may be required.

2. The establishment of a Selection Board with final responsibility for the selection of program participants.

3. To assist in the planning of a curriculum as may be required.

4. To study the need for additional courses in subsequent years as well as for a shorter course for this coming summer for engineering deans and other college administrators.

Submitted by

PHILIP N. POWERS
Chairman, ASEE Committee on Atomic Energy Education

November 13, 1955

Appendix F—The Institute Plan

The purpose of the Institute is to provide engineering college faculty members with training which will help them to incorporate nuclear engineering materials into their courses of instruction. It is proposed that the Institute be held at the Argonne National Laboratory during the summer of 1956 for eight weeks between June 20 and August 25. An outline of the material which should be covered is attached. Enrollment would be limited to sixty participants, and encouragement would be given to groups of two or four faculty members coming from single institutions. It is believed that interchange of ideas among these small groups would increase the carryover from the Institute to the college curricula.

It is further proposed that the Argonne National Laboratory provide this instruction without tuition charge and that stipends along with travel expenses be provided to the participants in sufficient amount to minimize financial hardships to those who attend. The colleges or universities involved would be expected to provide salaries up to $750 with matching stipends and travel expenses to be provided by the National Science Foundation.

Sponsorship of the Institute would be by the ASEE with the National Science Foundation, the Argonne National Laboratory, and Northwestern University serving as co-sponsors.

All administrative matters would be the responsibility of Northwestern University under the policy guidance of the Atomic Energy Education Committee of the ASEE. This would include the administration of the needed funds on behalf of ASEE. Selection of participants would be by a Selection Board to be established by the ASEE Committee. No racial segregation will be practiced.

The budget of expenses which require support by the National Science Foundation is as follows:

Matching funds for the conferees, assuming the average university contribution to be $600.00	$36,000.00
Transportation, calculated to average $150.00 per conferee	9,000.00
Expendable printing, supplies, telephone, accounting and other direct costs to Northwestern University	2,775.00
Total	$47,775.00

ANNOUNCEMENT OF ASEE INDUSTRIAL FELLOWSHIPS

RALPH A. MORGEN

Secretary, ECAC
Director, Purdue Research Foundation
Lafayette, Indiana

For the Committee on Industrial Fellowships

The information given below is published as a matter of record and for the benefit of Society members; it has already been distributed to Deans directly, and the selection of a recipient is well under way.

The American Society for Engineering Education is pleased to announce that it has accepted the generous offer of the Leeds and Northrup Foundation for the establishment of an Industrial Fellowship through the good offices of the Society. The Engineering College Administrative Council of the ASEE has been designated by President Boring to handle the matter for the Society. All communications relative to the Fellowship should be addressed as shown in the heading above.

The specifications of the award, the rules adopted by ASEE for its implementation, and the procedures to be followed are given below:

I. *The Grant*

1. A grant of $3,000 a year for a period of three years has been made to ASEE by the Leeds and Northrup Foundation.

2. The grant is made in recognition of the need for increasing the number of graduates in engineering at the Ph.D. level and for the support of fundamental research at institutions of higher learning.

3. This grant shall be known as ASEE-Leeds and Northrup Grant Number One.

4. It is the present intention of the Leeds and Northrup Foundation to initiate one of these $3,000 three-year grants each year until there will be a total of three such grants in operation at a time.

5. It is a request of the donor that the grants should generally be rotated in the fields of electrical, mechanical, and chemical engineering, but not on a mandatory basis. The availability of suitable candidates may make it desirable to depart at times from any systematic rotation.

6. The selection of both the student and the school shall be the responsibility of the ASEE (See regulations below).

7. The institution receiving the award shall use the funds as follows:

(a) An appropriate stipend to the student, which may be considered a free grant not subject to income tax.

(b) Ordinary tuition to the institution receiving the award.

(c) The balance to be used by the institution as it sees fit to make up the difference between tuition and actual costs of instruction.

8. In the case where the candidate selected has already obtained a master's degree, so that only two addi-

tional years will be required to obtain the doctorate, the ASEE may use the funds for the additional year to support graduate research leading to a master's degree in engineering.

9. In the event that any candidate chosen by ASEE to carry out this program ceases to qualify or be available, the funds made available under the commitment may be used by ASEE in any manner directed in its best judgment toward carrying out the intent of the donation.

II. *Eligibility and Rules for the Academic Year 1956*

1. Eligibility is limited to institutional members of ASEE.

2. The appropriate Deans of Engineering and Deans of the Graduate Schools are advised of the availability of the grant by this notice.

3. In order for an institution to be eligible for this particular award, one or more of its three departments—Mechanical Engineering, Electrical Engineering, or Chemical Engineering—must have granted a minimum of three Ph.D. degrees between January, 1950 and June, 1955, inclusive.

4. The institution must accept or decline the invitation by January 15, 1956, in order to be available for this year's support. A reply is requested as to whether or not the institution is eligible under the rules or wishes to accept the invitation.

5. Accompanying the institution's request to be included in this year's award should be the list of students who have received the Ph.D. degree and their thesis titles in an appropriate area between the indicated dates.

6. The Committee on Industrial Fellowships of ECAC will then select the institution by a random distribution method. Each institution will have one chance regardless of the size of the institution just as long as it meets the minimum requirements of Ph.D. awards. The committee will advise the successful institution of the award by February 15, 1956.

7. The institution will then select an appropriate graduate student, who in its opinion is or can become a candidate for the Ph.D. degree in one of the three areas—Mechanical, Electrical or Chemical Engineering. The award will be made for the fiscal year beginning July 1, 1956. When the student has been selected, his name and qualifications should be sent to the Secretary of ECAC. If the institution originally awarded the grant is unable to select a student before April 1, 1956, it should so advise the secretary of ECAC. The Committee on Industrial Fellowships shall then select, by a random distribution method, another institution; that institution shall then have thirty days in which to select an eligible student.

8. The student and the institution shall retain the Fellowship as long as the student continues to maintain his status at the University, until the Ph.D. degree is awarded or for three years, whichever comes first. The award may not be transferred to another student.

9. Any unused balance from the three-year fellowship shall be retained by ASEE through its Committee on Industrial Fellowships. Rules shall be formulated for distribution of any such balance and shall consider the possibility of awarding one or more Fellowships at the master's degree level in the appropriate disciplines designated by the donor.

FUNCTIONS OF THE ENGINEERING ECONOMY COMMITTEE

ARTHUR LESSER, JR., Chairman

Editor, "The Engineering Economist"

Humphreys Professor of the Economics of Engineering, Stevens Institute of Technology, Hoboken, New Jersey

With the assistance of Anatole Gruehr, Brooklyn Polytechnic Institute, and Norman N. Barish, New York University.
The following statement is published not only for its inherent interest, but also to assist members of the Society in evaluating the request of the Committee for Divisional Status.

Engineering Economy is concerned with decision-making in respect to the economic evaluation of alternative engineering objectives, designs, specifications, and systems (men and machines).

These situations concern themselves with any branch of engineering activity, electrical, mechanical, civil, chemical, industrial, etc., or a combination of two or more branches. Thus, engineering fields supply the technical criteria to the engineering economist: economic factors supply the methods of evaluation; accounting and statistics supply the base data and appropriate techniques.

Engineering Economy aims at optimizing the economic outcome of the project under consideration by the proper choice among alternatives. This involves the best proportioning and most economical use of resources, both material and human, as well as the consideration of anticipated revenues.

As far back as 1925, a Clearing House of Engineering Economy was set up at Stanford University, California, coinciding with the formation of a School of Engineering at that University. This was an informal interchange of papers, examinations, and viewpoints carried on under the direction of J. C. L. Fish of Stanford.

Within the framework of the ASEE (then SPEE) a conference on the Teaching of Engineering Economy was first held in Atlanta in 1935, under the sponsorship of the Industrial and Mechanical Engineering groups of that society. In 1936, a Committee on Engineering Economy was appointed with Eugene L. Grant of Stanford University as Chairman. In May of 1937, a regular page in the JOURNAL OF ENGINEERING EDUCATION was devoted to Engineering Economy, with Edmund D. Ayres as Editor. This page—a more formal continuation of the Clearing House—continued until 1943.

In addition to the activities of the Engineering Economy Committee, the ASEE on three occasions, in 1932, 1936 and 1937,

held summer schools on economics with considerable emphasis on subjects of specific concern to enginering economists.

In 1954 a Summer School for Engineering Economy was held in connection with the annual meeting of the ASEE at the University of Illinois. Papers were delivered by a number of pioneers —Eugene L. Grant, Paul T. Norton, E. Paul De Garmo, Clarence Bullinger. The School also afforded opportunity for presenting the viewpoints of some of the newer men in the field. The program thus assembled speakers who gave papers on three areas. First were the background papers in the areas of Economics, Accounting, and Statistics. Next was a series on Theory and Practice in Engineering Economy and lastly consideration was given to Operations Research and its relationship to Engineering Economy. The Proceedings of the Summer School were published at cost. This publication was purchased by individuals and institutions throughout the nation and is now out of print.

The Summer School summarized the contribution made by Engineering Economy in the past, when the level of empiricism in our technical work was relatively high. It further pointed to the potential role of Engineering Economy in such methodologies as Operations Research and Decision Theory which are evolving as a result of the complexity and growth of industry, the high cost and scarcity of resources—both material and human, and the rapid acceleration of technological change through automation.

Since engineering economy is a discipline applicable to all engineering fields, there is no technical society exclusively devoted to the advancement of theory and practice in engineering economy. The Engineering Economy Committee of the ASEE has provided a medium for the interchange of ideas of those active in the field as well as the development of improved pedagogy. To help implement the work of the Committee, *The Engineering Economist,* to be published quarterly, has been started. The first issue contained an article, "Linear Programming for the Engineering Economist," by Adam Abruzzi. It is the aim of the Committee to seek further challenging papers that would be appropriate for a specialized publication of this type.

ASEE ANNUAL MEETING

June 25–29, 1956

Iowa State College

—— AIM FOR AMES IN 1956 ——

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

October 19, 1955

To: Members of Engineers' Council for Professional Development 1954–1955 and 1955–1956

Gentlemen:

There is enclosed a resolution adopted unanimously by the members of the 1954–1955 Council present at the Annual Meeting at Toronto, Canada, on October 14, 1955. This resolution recommends that ECPD sponsor a comprehensive survey of the engineering profession and seeks the approval and support of its Constituent Societies.

Accompanying the resolution is a preamble outlining briefly the development of the proposal and a copy of an address by Dean S. C. Hollister before the Annual Meeting which presented the subject for subsequent panel discussion at the meeting.

This information is being circulated promptly to members of Council with copies to the Secretaries of the Constituent Societies, so that the actual facts will be before those concerned. However, it is obvious that a more explicit statement with suggestions for implementation be received by the Constituent Societies before they take formal action, unless the information presented herewith is sufficient to warrant some form of general endorsement and support.

The Executive Committee of ECPD will meet on December 5, and shortly thereafter a more comprehensive statement and suggested program will be transmitted to ECPD and to the Constituent Societies.

It is my hope that the inauguration of a well-considered survey of the engineering profession will stir the imagination and meet with enthusiastic response of the governing boards of our Constituent Societies, and that its consummation will constitute a significant milestone in the history of engineering as a profession and in the esteem in which it is held by the public.

Sincerely yours,

THORNDIKE SAVILLE
President, 1955–1956

RESOLUTION ON SURVEY OF THE ENGINEERING PROFESSION

Adopted at the Twenty-Third Annual Meeting of ECPD on October 14, 1955.

WHEREAS: The Profession of Engineering has ever increasing responsibilities in the rapidly expanding technological aspects of our civilization, and

WHEREAS: these public and professional responsibilities are becoming increasingly complex, and

WHEREAS: the numbers of engineering personnel being trained are both limited in supply and inadequate in numbers to discharge the needs under the present organization of the profession, much less those of the future, and

WHEREAS: the situation confronting the profession is charged with important social, economic, and political aspects in the interest of the public welfare, and

WHEREAS: in the light of these serious public and professional problems a study of the profession is called for, now therefore

LET IT BE RESOLVED: That Engineers' Council for Professional Development sponsor a survey of the Engineering profession to include the present and prospective needs for engineering services, the improvement in the utilization of engineers and supporting technical personnel, the scope and nature of the education and training required, the problems of registration, unionization and ethics involved, and all other matters pertinent to determine the most effective organization of the profession to meet its public responsibilities and professional opportunities, and

BE IT FURTHER RESOLVED: that Engineers' Council for Professional Development seek the concurrence of its Constituent Societies in undertaking such a survey, and

BE IT FURTHER RESOLVED, that Engineers' Council for Professional Development refers this resolution to its Executive Committee for implementation.

NOTES ON ORIGIN OF PROPOSAL FOR SURVEY OF ENGINEERING PROFESSION

WARREN L. McCABE

ECPD Executive Committee

In June, 1954, an informal meeting of engineering deans was called by Dean Hollister at Ithaca, New York. Ten deans accepted the invitation and conducted a two-day discussion at Ithaca on the basic situation and unsolved problems of the engineering profession.

This meeting was stimulated by the work of the American Society for Engineering Education's Committee on Evaluation of Engineering Education. In the course of its activities, the Committee on Evaluation had run head-on into a number of unsolved problems having to do with the profession as a whole. The Ithaca group was also concerned with the fact that although the supply of engineers, as a fraction of the oncoming generation, is a constant and probably has reached its practical maximum, the demand for engineering services based on the total population is increasing exponentially. Not only are important short-range problems involved but a critical long-range problem also emerges from this fact.

The result of the Ithaca meeting was a statement proposed by Dean O'Brien and accepted by the deans' conference on Wednesday, June 23, 1954. A copy of this statement is attached as Appendix 1.

It was agreed that further impetus to this proposal be placed in the hands of Deans T. Saville and S. C. Hollister. On February 23, 1955,

Dean Hollister addressed a communication to Colonel L. F. Grant, President of Engineers' Council for Professional Development. With this letter was forwarded the statement prepared by the ten deans.

On receipt of this communication, Colonel Grant brought the matter to the attention of the Executive Committee of ECPD. At the March meeting of the Executive Committee, Colonel Grant requested Mr. Morris D. Hooven, Vice-President of ECPD (currently President, AIEE) to study carefully the statement of the ten deans and report back with suggestions for possible Council action.

Mr. Hooven reported by means of a letter to Colonel Grant dated July 12, 1955, and presented a short survey of the future composition of the various professional classes important to our national life.

At its meeting of July 28, 1955, the Executive Committee acted and passed Minute 1111, entitled, "The Survey of Engineering Education and Utilization of Engineers." This Minute is attached to this memorandum.

Acting upon the resolution of Minute 1111, two items in the program of the 23rd Annual Meeting of ECPD held on October 13 and 14, 1955, at Toronto, Ont., Canada, were devoted to the problem. The first was an address by Dean Hollister at the luncheon meeting of October 13. The second item was a panel discussion scheduled during the afternoon of Friday, October 14, 1955. This discussion was led by Warren L. McCabe, with the assistance of the following panel: H. N. Meixner, E. I. du Pont de Nemours & Company; M. D. Hooven, Public Service Electric & Gas Company; R. M. Hardy, Dean of Engineering, University of Alberta, Edmonton, Alberta, Canada; Dean Thorndike Saville, New York University; Dean W. L. Everitt, University of Illinois.

At the conclusion of the discussion, which was participated in by many members of the audience, the Council passed a resolution addressed to the Executive Committee, requesting the Executive Committee to proceed with plans for conducting the proposed survey and finding appropriate leadership and financial support for it.

ASEE SUMMER SCHOOLS FOR 1956

Civil Engineering and Construction. Sponsored by the Civil Engineering Division, June 29 to July 1, Iowa State College, Ames, Iowa. Information from Professor C. Martin Duke, University of California, Los Angeles, California.

Engineering Drawing. Sponsored by the Engineering Drawing Division, June 20–24, Iowa State College, Ames, Iowa. Information from Professor W. E. Street, Drawing Department, Agricultural and Mechanical College of Texas, College Station, Texas.

Humanistic-Social. Sponsored by the Humanistic-Social Division, June 28–30, Iowa State College, Ames, Iowa. Information from Dr. Melvin Kranzberg, Social Studies, Case Institute, Cleveland, Ohio.

THE NEED FOR AN APPRAISAL OF THE ENGINEERING PROFESSION

S. C. HOLLISTER

Dean, College of Engineering
Cornell University
Ithaca, New York

An address presented at the Twenty-Third Annual Meeting of ECPD
Toronto, Canada, October 13, 1955

There is no doubt that during the past quarter century the tempo of the whole world has increased to an astonishing degree. Through developments in engineering, our communications and transportation systems have created the illusion that the world is shrinking so that it is now practically only a fraction of the size it used to be. Because of this tremendous change in communications and transportation, the world political arena has been completely altered. Mass attitudes are being built up or broken down.

The engineer is at the core of this development. His group has created many of the technical means which have brought about this change and in many instances has participated in the direction of its development. To an increasing degree he is becoming a practicing sociologist, an active economist, a political planner, all in addition to his functioning as one who interprets scientific principles into useful works.

While human and international relationships have been shifting at a remarkable rate—a shift in which the engineer's work has been an active ingredient—the very basis of his technical accomplishments, namely, the fund of scientific knowledge, also has been enormously expanded in this period of time. One can only partially dream of the tremendous ramifications of this new knowledge and the extent to which it may be applied to human service.

The public has become aware of the many accomplishments of the engineering profession having a bearing on our daily life—accomplishments that bring men closer together, that unify their problems and common concerns, that lighten their burdens and extend their capacities, and that enhance the common welfare.

Engineers have accomplished so much that now it is taken for granted that what they produce will function without difficulty. It is further taken for granted that they will safeguard the life and property of the public. Nobody stops at the end of a bridge to make computations to see whether or not he should cross the bridge. There is still another public assumption that puts a tremendous responsibility upon the engineer. He has worked so many miracles in the eyes of the public that it is now assumed that he will bail mankind out of any crisis that may arise. Take for example our present headlong dash toward consuming our natural resources. If the question is raised that perhaps we should be more cautious we are told at once that when the pinch comes

they will find something else that probably will be better. "They" in this case means the engineer.

It is easy to see, therefore, that the engineer has assumed in the mind of the community a professional status. As a group, engineers have become a definite entity both as to function and accomplishment in the public mind. This is true regardless of whom the engineer works for or what are the arrangements of his employment.

The services engineers are being called upon to render are increasing not uniformly with time, but exponentially. We know that there are many things on the shelf waiting to be worked upon. We know that new knowledge, useful for the engineer, has been increasing at a tremendous rate. We know also that even with the normal development of former lines of engineering, new avenues of approach are opening in many directions. Thus, not only as time goes on, but also with the increase in population, the services engineers need to render are increasing at a faster and faster rate.

There is much evidence to show that only a certain proportion of our population has the necessary qualifications to undertake the engineering profession. Many of those qualifications are similar to those required for success in other lines. Out of a given age group, that is, for example, out of the number of boys reaching age eighteen in a given year, only about seventeen per cent have the necessary intellectual capacity to undertake work in our profession. This same seventeen per cent, however, must also supply the talent for other professions, as law, medicine, science. They must also supply the top-level people in the crafts, including the better chefs, cabinet makers, glassblowers, tool makers, and the like. The interplay of interests, the degree of enterprise or of fortitude, will have a bearing upon which field the boy enters for study.

Several years ago I was able to point out that only about 47,000, amounting to one-fourth of the seventeen per cent I mentioned, could be expected to enter the engineering profession at the freshman level. We have, through the beating of drums and the shaking of bushes, gone higher than this number. A study of performance in college, however, points out that it is quite apparent that after we passed approximately 47,000 the mortality rate took a sharp increase. In other words, it would seem we are dipping a little further into the supply and reaching a little below the likely level of capacities.

In speaking of this matter of intelligence, the capacity for receiving a particular kind of education, it must be borne in mind that we are doing so in the light of our educational methods, our guidance systems, and the manner in which we communicate to the oncoming youth the possibilities and attractiveness of the various professions and other occupations which he might conceivably be capable of entering. We need to make improvements in all of these methods of communicating with the youth and we need improvement all along the line in educational operations. These, however, are not going to be changed suddenly. It will be a long process of evolution if we are to make any changes, but we must continually try.

Returning now to the meaning of our experience of the success and failure of boys attracted to the engineering profession, it is apparent that we

have reached a fixed percentage of the population that will enter engineering. When we look again at the services that engineers are being called upon to perform and the fact that these service needs are increasing at an accelerating rate, we see that the demand for services is outrunning the rate of supply of people to perform them. This does not necessarily mean that we have to go without such services, at least not for the present.

It does mean, though, that the pattern of utilization of engineers must be modified considerably. We know that in many fields the beginning engineer soon progresses to paper work and from there to administrative duties and frequently to less and less engineering contribution. The pattern of advancement is often in lines other than engineering. It is necessary to modify this state of affairs so that the path and the rewards lie closer to engineering practice. In this respect we can take a leaf out of the book of the medical profession where the number of doctors is about half the number of engineers.

Any clinical doctor performs as the nucleus of competent but less trained people and in such a way the ability of the doctor is proliferated over a wider contact area. To some degree the legal profession is organized along similar lines. The engineering profession, if it is to render the services that we know are ahead of it, must be considerably overhauled both in the manner of utilization and in the pattern of preparation for such a career.

There are already signs of threats to the profession that should motivate us to prepare soon for a re-evaluation of our professional activities. On the one hand, scientists are entering the field, in many cases with telling effect. They have better fundamental training and for the most part they are able to stay in the professional field without shift to administrative function. At the other end of professional activity we are feeling the effects of unionization in areas where large numbers of young engineers may be used in more or less standardized and routine functions. We have become, in a part of the profession at least, slaves to job classification rather than men working toward the utilization of individual talents in their highest form.

In the foregoing remarks I have simply presented my personal impressions of the situation in the profession. Most of them are qualitative. Many of them are in some degree controversial. What is lacking in this critical situation is an accurate, carefully made appraisal of both utilization and supply.

Suppose, for example, we have a scientific sampling of each school of engineering and we followed the progress of each graduate in the sample. If we did this for different classes of graduates we would amass a body of material that would give us a consolidated picture of the training, development, growth, utilization, and accomplishment of the individuals in the profession. We would then be able to note with some assurance the factors to which we could most profitably give attention.

It is clear, or so it seems to me, that the profession is badly in need of a comprehensive survey having as its objective the evaluation and appraisal of its present and likely future adequacy, and an appraisal of the areas in which action must be taken to effect indicated improvements.

This Council asked in 1952 for an appraisal of the preparation of engineers and referred the matter to the American Society for Engineering Education. That Society has completed such a study and during the current year has published its report. It is a useful and important study and if implemented will, I am sure, contribute to the progress of the profession. But at the same time one is impressed with the fact that it deals with but one facet of a very much larger problem, a problem that the educators may see but can do nothing about.

A notable study was made of the medical profession about forty years ago which culminated in the famous Flexner Report. This report has had a profound effect upon the development of the medical profession and has strengthened the effectiveness of that profession in its services to the community. In consequence it has contributed greatly to the stature of the medical profession in the eyes of the community.

More recently, a similar study has been undertaken in the legal profession. It is too early to mark the results but undoubtedly similar benefits will derive from it.

It would seem clear that everybody stands to gain by a well-executed study of this sort. First of all the community would be served by any improvement that could be brought about in the functioning of our important profession. Those immediately concerned with function, namely, the employers of engineers and the engineers themselves, would profit both individually and collectively by such a well-designed and well-executed survey. And finally, such a survey should lay the groundwork for improvement and better definition of the engineering profession as a whole.

Who should sponsor such an undertaking as this? It has been suggested that each of the professional branches should undertake a study of its own. One only needs to recall the interweaving of the services of the separate branches, the extent to which they have a relatively common background, the fact that in many cases their talents and efforts impinge upon the same general problem, and the fact that many, trained in one branch, actually serve through their professional lives in another branch, to realize that there would be duplication, waste of effort, waste of money, and in general unnecessary confusion if the study were to be made in that manner. Furthermore, it seems to me that such a study needs background that can be obtained only through the guidance of an organization whose principal objective is the development of the engineering profession in all aspects. Clearly then, the sponsor for such an operation should be the Engineers' Council for Professional Development.

What is needed to accomplish such a survey? It would seem appropriate to set up an advisory board from the engineering profession to give guidance to the inquiry itself. This board should represent the various branches of engineering. It should represent different elements of the structure of the profession and different ways in which these elements function. It should be as small and compact as possible. It should report to this Council.

Under such a board should be organized a competent full-time staff to conduct the survey. It should be headed by a full-time director. It

should be staffed with specialists appropriate to the different lines of inquiry.

It would be essential that the operation be adequately financed since it is conceivable that the cost of such a survey would in the end amount to as much as a million dollars. There seems no question, however, that the benefits to be derived by the community are so great that such a sum becomes unimportant in proportion to the benefits.

As I view our profession and with quiet pride appraise its accomplishments, I feel at the same time a sense of the heavy responsibility that is placed upon us to discharge the enormous volume and range of function that we face. As I look ahead it seems to me that this range and volume grows to staggering proportions and must develop within us all a great sense of urgency to perfect the structure of our profession so that it may continue in its great tradition. I see no greater service that this Council can perform, either to the profession or to the community, than to bring into being such an organization, designed for the appraisal and for the guidance and further development of our profession. I believe that both for the profession and for the community we have arrived at a stage where time is now of the essence.

SOVIET SECONDARY EDUCATION

An article on "Soviet Secondary Education—designed to achieve future scientific supremecy," by Eleanor S. Lowman, specialist in Soviet Education in the International Education Division, U. S. Office of Education, in the December, 1955, issue of *Higher Education* presents an interesting contrast with American public and private preparatory school practices. Commenting on the utilitarian nature of the Russian program, which is placing increased emphasis on scientific and technical training, expanding the rate of high school-equivalent graduations, and orienting the secondary curriculum to one of greater value for sub-profession technicians and laborers, sharp differences are pointed out between humanistic and technical curricula in the U. S. and in Russia.

Each of the more than one million students graduating from Russian secondary schools last June, said the article, had taken five years of physics, one year of astronomy, four years of chemistry, five of biology, and ten of mathematics, including algebra, geometry, and trigonometry. At the same time, the USSR has been directing teacher training into scientific areas so that there will be no shortage of secondary school instructors. The Soviets are building large secondary schools and universities, and have raised their entrance requirements. All this is apparently directed, however, not only to preparation for professional work, but increasingly toward filling the manpower shortages at practical and sub-professional levels.

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1956).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at Iowa State College, June 28, 1956.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.

The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant engineering practice in the next 15 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences?
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1956. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1956.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

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Engineering Enrollments and Degrees, 1955*

By WILLIAM A. JARACZ and HENRY H. ARMSBY **

Engineering enrollment has increased for the fourth consecutive year—after successive annual declines from a post-World War II high of 244,390, in 1947 [1] to a post-World War II low of 147,694 in 1951. There were 211,923 engineering students enrolled (at all levels) in institutions accredited by the Engineers' Council for Professional Development in 1955, or 13.1 per cent more than were enrolled in such schools in 1954. This constitutes a considerable increase—larger, in fact, than that experienced by higher educational institutions in general.[2] Total enrollment in all institutions of higher education increased 8.8 per cent, and male enrollment, 11.4 per cent. The 1955 increase of 13.1 per cent continues the trend in the direction of an annual increase in the rate of increase in engineering enrollment. The 1954 enrollment exceeded that of 1953 by 9.1 per cent; the percentage increases in 1953 and 1952 were 8.4 and 7.3, respectively. Engineering enrollment (at all levels) increased by about one-third (33.7 per cent) from 1952 to 1955.

Enrollment of Freshmen

With respect to new-student enrollment, the gain made by engineering schools (10.1 per cent) is considerably larger than that experienced by higher educational institutions generally (7.3 per cent). This difference, however, becomes less pronounced when the 10.1 per cent increase in engineering freshmen is compared with a 8.7 per cent increase in the first-time male enrollment in higher educational institutions as a whole. Inasmuch as engineering enrollment is predominantly male, sufficient justification exists for comparing enrollment in engineering schools with the male enrollment in all higher educational institutions.

The increase of 10.1 per cent in the enrollment of engineering freshmen in

* All engineering enrollment and degree data presented in the text of this report are restricted to schools accredited by the ECPD. All such schools responded to requests for data. A report which analyzes engineering enrollment and degree data for all institutions which grant engineering degrees, including those not accredited by the ECPD, will be published in the near future by the U. S. Office of Education (Circular No. 468, *Engineering Enrollments and Degrees, 1955*).

** Mr. Jaracz is Head, Statistical Services Section, Research and Statistical Services Branch, Office of Education, U. S. Department of Health, Education, and Welfare. Dr. Armsby is Chief for Engineering Education, Division of Higher Education. The authors would like to acknowledge their indebtedness for contributions made during the several stages in the preparation of this report to the following: Hazel Poole and Elizabeth Bentson of the Statistical Services Section staff, who were under the supervision of Mabel C. Rice; and Ellen S. Scala, secretary to Dr. Armsby.

[1] All enrollment data presented in this article are for the fall of the year cited; all degree data, for the 12-month period ending June 30 of the year cited.

[2] Enrollment data for all institutions of higher education are taken from Circular No. 460, *Opening (Fall) Enrollment in Higher Educational Institutions 1955* (U. S. Office of Education), and degree data for all institutions, from Circular No. 461, *Earned Degrees Conferred by Higher Educational Institutions 1954–1955* (U. S. Office of Education).

1955 takes on considerable significance in view of the fact that the number of engineering freshmen increased at a declining rate in the three previous years. The increase in 1952 was 34.3 per cent; in 1953, 14.5 per cent; and in 1954, 5.8 per cent. Hence, not only was the increase in the enrollment of engineering freshmen almost twice as great in 1955 as in 1954, but also, it put a halt to the decline in rate of increase.

A comparison of first-time enrollment for the Nation as a whole with freshmen enrollment in schools accredited by the ECPD for the past few years brings to light certain dissimilarities. The post-World War II low for first-time enrollment in all institutions came in 1951, whereas the corresponding low for engineering freshmen came one year earlier, in 1950. As a result of this, a decline in first-time enrollment in all colleges in 1951 was accompanied by an increase of 16.2 per cent in the enrollment of engineering freshmen. In 1952 and 1953, there were increases both in total first-time enrollment and in freshmen engineering enrollment, the latter being greater in each year. The increase in the enrollment of engineering freshmen in 1954, however, was smaller than the increase in first-time students generally. But in 1955, as indicated above, the increase in engineering freshmen was again greater than the increase in first-time enrollment generally.

The foregoing examination of freshmen engineering enrollment and the enrollment of first-time students in all higher educational institutions can be brought into sharper focus by expressing the former as a ratio of the latter. These ratios for the past six years were as follows:

1950	5.7 per cent
1951	7.2 per cent
1952	8.5 per cent
1953	9.2 per cent
1954	8.6 per cent
1955	8.9 per cent

Undergraduate Enrollment

Undergraduate engineering enrollment, as is true of engineering enrollment generally, increased for the fourth consecutive year. The 190,355 undergraduate engineers enrolled in 1955 represented an increase of 13.9 per cent over the undergraduate engineering enrollment in 1954. In view of the fact that the increases had been 7.6 per cent, 8.9 per cent, and 11.1 per cent, respectively, for the three years 1952 to 1954 inclusive, it is apparent that undergraduate engineering enrollment has been increasing at an increasing rate.

The undergraduate engineering enrollment was distributed by class level, in terms of percentages, as follows: 32.1 per cent were freshmen; 23.0 per cent, sophomores; 18.2 per cent, juniors; and 14.6 per cent, seniors. Students in the 5th year of 5-year programs accounted for 1.2 per cent of the undergraduate engineering enrollment; and the remaining 10.8 per cent were part-time and evening students. These percentages were essentially those which obtained in 1954. There was an increase in enrollment at all class levels with the exception of 5th year students, in the case of which there was no change. The increase in part-time and evening students (5.2 per cent) was much smaller than in 1954 (15.6 per cent).

Almost three-fifths (57.5 per cent) of all undergraduate engineering students were enrolled in three of the engineering curricula: electrical (24.1 per cent), mechanical (20.9 per cent), and civil (12.5 per cent). The corresponding figures for 1954 were 56.0 per cent for the three curricula combined, 22.1 per cent for electrical engineering, 21.0 per cent for mechanical, and 12.9 per cent for civil.

Unclassified Undergraduates

Of the total undergraduate enrollment, 16.2 per cent consisted of students who were unclassified with respect to the particular engineering discipline they planned to pursue. In 1955, 94 schools reported

a total of 30,779 unclassified students. The same number of schools reported unclassified enrollment in 1954, and such enrollment constituted approximately the same proportion (16.3 per cent) of the total undergraduate enrollment. The greater part of such students are found in the freshman class and among the evening students. In 1955, 31.9 per cent of the freshman class and 44.3 per cent of all undergraduate evening students were unclassified. Approximately the same percentages prevailed in 1954: 30.3 per cent of the freshman class and 44.6 per cent of undergraduate evening students were unclassified.

First Degrees

The number of male students who earned undergraduate engineering degrees in 1955 was 2.5 per cent larger than the number in the previous year. This increase compares favorably with a decline of 9.1 per cent in the number of male undergraduates granted engineering degrees in 1954, and with the decline of 2.1 per cent in the number of first degrees conferred on male students in all institutions of higher education in 1955. Of all first degrees granted to male students by all degree-granting institutions in 1955, 11.0 per cent were in engineering. The 1955 ratio appears to have stopped a trend in the direction of increasingly smaller ratios which had prevailed in the three previous years: 11.9 per cent in 1952, 10.8 per cent in 1953, and 10.5 per cent in 1954.

The number of first engineering degrees declined annually from the peak year 1950, when 48,160 were conferred, to 1954, when 19,707 were conferred. This situation reflected the decline in freshmen enrollment after 1946. The small number of first engineering degrees conferred in 1954 can be attributed to the fact that the entering freshman class of 1950 was the smallest in the post-World War II period. The 1955 increase in first engineering degrees is expected to be an annual occurrence for the foreseeable future; i.e., such increases will reflect the annual increase in freshmen enrollment subsequent to 1950.

In 1955, almost two-thirds (65.9 per cent) of all first engineering degrees were conferred in three fields of engineering: 26.0 per cent in mechanical, 22.3 per cent in electrical, and 17.6 per cent in civil. Mechanical and electrical engineering showed increased strength, while civil engineering declined somewhat in relative importance. The corresponding figures for 1954 were 63.5 per cent for the three curricula combined; 24.5 per cent for mechanical, 20.7 per cent for electrical, and 18.3 per cent for civil.

Graduate Enrollment

Every post-World War II year, with the exception of 1954, has witnessed an increase in graduate engineering enrollment. In 1954, there was a net decline of 1,055 graduate students—resulting from an increase of 278 students enrolled in work leading to a doctoral degree, and a decline of 1,333 students enrolled for work leading to a master's or other predoctoral degree. In 1955, on the other hand, there was a net increase of 1,217 graduate students—resulting from an increase of 1,335 enrolled for work leading to a master's or other predoctoral degree, and a decline of 118 students enrolled in work leading to a doctoral degree.

A considerable, but declining, proportion of students working for a master's or other predoctoral degree were evening students. The proportions for the last four years were the following: 57.4 per cent in 1952, 56.1 per cent in 1953, 51.4 per cent in 1954, and 48.7 per cent in 1955. A considerably smaller proportion of doctoral students were evening students. This proportion declined considerably in 1955, after small annual increases in the three previous years. The proportions for the last four years were the following: 22.8 per cent in 1952, 23.4 per cent in 1953, 24.3 per cent in 1954, and 16.1 per cent in 1955.

The increase in graduate engineering

enrollment in 1955, following a decline in 1954, is gratifying in view of the great demand for engineers with advanced educational attainment. The large proportion of graduate engineering students who attend classes during the evening indicates an awareness on the part of practicing engineers of the necessity for bettering their understanding of the complex engineering processes which are constantly being developed.

Graduate engineering enrollment has, nonetheless, accounted for a diminishing proportion of total engineering enrollment for the past few years. The ratios for the past five years 1951 to 1955, respectively, were: 13.1 per cent, 12.8 per cent, 12.5 per cent, 10.9 per cent, and (in 1955) 10.2 per cent. The ratio of resident graduate enrollment to total resident enrollment for the college population as a whole was 10.0 per cent in 1954 (the latest date for which such data are available).

As was indicated above, the largest number of undergraduate engineering students are found in electrical, mechanical, and civil engineering—in that order. Chemical engineering, however, replaces civil as one of the big three with respect to graduate engineering enrollment. The enrollment in civil engineering at the master's level is larger than that in chemical engineering; the enrollment in chemical engineering at the doctoral level, however, far exceeds the enrollment in civil engineering.

Approximately three-fifths (57.6 per cent) of all graduate engineering students were enrolled in electrical, mechanical, and chemical engineering. Graduate students in electrical engineering made up 30.0 per cent of the total graduate engineering enrollment, mechanical and chemical engineering being 16.1 per cent and 11.4 per cent, respectively. The corresponding figures for 1954 were 59.6 per cent for the three disciplines combined; 31.0 per cent for electrical engineering, 17.0 per cent for mechanical, and 11.5 per cent for chemical.

Graduate Degrees

The 7.6 per cent increase in the number of master's degrees conferred in engineering is considerably greater than the 2.4 per cent increase in master's degrees conferred by all degree granting institutions. This increase, although smaller than that which obtained in 1954 (11.4 per cent), constitutes a considerable change from the situation which prevailed in 1952 and 1953, in each of which years the number of master's degrees declined.

There was an increase of 1.5 per cent in the number of engineering doctorates conferred. In actual numbers: 599 were conferred in 1955, as compared with 590 in 1954. The number of doctorates conferred by all higher educational institutions, on the other hand, declined 1.7 per cent.

Summary

1. Engineering enrollment in ECPD accredited schools increased for the fourth consecutive year; by 13.1 per cent in 1955.

2. The 13.1 per cent increase in engineering enrollment compares favorably with an 11.4 per cent increase in male enrollment in all institutions of higher education.

3. Similarly, the 10.1 per cent increase in engineering freshmen compares favorably with an 8.7 per cent increase in male first-time enrollment in all higher educational institutions.

4. Undergraduate engineering enrollment increased 13.9 per cent, and has been increasing at an accelerating rate.

5. Almost three-fifths (57.5 per cent) of all undergraduate engineering students were enrolled in electrical, mechanical, and civil engineering.

6. About one-sixth (16.2 per cent) of the engineering undergraduate enrollment consisted of unclassified students, mainly freshmen and evening students.

7. In 1955, there was an increase of 2.5 per cent in first engineering degrees conferred on male students, as contrasted with a decline of 9.1 per cent in 1954.

This compares favorably with a decline of 2.1 per cent in the total number of first degrees conferred on males in all degree-granting institutions.

8. There was an increase of 1,335 predoctoral graduate students, but a decline of 118 doctoral students.

9. About one-half (48.7 per cent) of the predoctoral graduate students were evening students; and about one-sixth (16.1 per cent) of the doctoral students.

10. About one-tenth (10.2 per cent) of the total engineering enrollment consisted of graduate students.

11. About three-fifths (57.6 per cent) of all graduate engineering students were enrolled in electrical, mechanical, and chemical engineering.

12. There was a 7.6 per cent increase in master's degrees in engineering, as compared with a 2.4 per cent increase in master's degrees conferred by all degree-granting institutions.

13. There was a 1.5 per cent increase in engineering doctorates, as compared with a 1.7 per cent decline in doctorates conferred by all degree-granting institutions.

Notes

The data contained in this report are based on a survey of engineering schools and colleges made in October 1955, under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by a joint committee of the Office of Education and the ASEE, all institutions listed in the Office of Education Directory of Higher Education [3] which reported the conferral of degrees in engineering during 1954–55 [4] were requested to furnish data. Ten Canadian institutions were also invited to participate in the study. This report contains enrollment and degree data for all institutions accredited by the ECPD, 68 other United States institutions, and 10 Canadian institutions.

As proposed by the joint ASEE and Office of Education Committee and approved by the ASEE General Council, the statistical tables in this report list individually only those institutions (eligible for active institutional membership in the ASEE) in which at least one curriculum has been accredited by ECPD, but contain summary totals for other engineering schools in the United States and for Canadian institutions.

Requests for the data upon which this report is based were directed to the registrars of the institutions concerned. The Office of Education appreciates the splendid cooperation of these officials, as is reflected by a 100 per cent response.

Period covered: Engineering schools were asked to report student enrollment as of October 3, 1955. A few institutions, because of late openings, were unable to report before November. Degree data are for the period July 1, 1954 to June 30, 1955.

Undergraduate students: Institutions were requested to report by class level only those students enrolled definitely as candidates for an engineering degree. "Part-time students" (both day and evening) include students not working toward a degree, as well as degree candidates.

Graduate students: Institutions were requested to "report all students who have been admitted to formal graduate standing and are enrolled in graduate courses regardless of the number of credit hours carried by the student, and regardless of whether the student's work is administered by the engineering college or the graduate school."

[3] *Education Directory, Part III, "Higher Education, 1954–1955"* (U. S. Office of Education).

[4] *Earned Degrees Conferred in Higher Educational Institutions, 1954–1955* (Circular No. 461, U. S. Office of Education).

COMPARISON OF PRE-WAR AND POST-WAR ENGINEERING COLLEGE ENROLLMENTS AND DEGREES

(for United States and outlying parts)

Undergraduate Enrollment and Degrees

Year	Freshmen	Sophomore	Junior	Senior	5th Year	Part Time and Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	14,079	108,911	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	18,616	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	17,932	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950*	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)
1951*	34,147	23,408	24,757	27,820	2,946	15,289	128,367	37,904 (1950–51)
1952*	45,854	26,636	22,369	23,453	2,563	17,295	138,170	27,155 (1951–52)
1953*	52,482	32,953	23,975	21,730	2,396	16,890	150,426	21,642 (1952–53)
1954*	55,531	38,345	28,699	22,677	2,323	19,528	167,103	19,707 (1953–54)
1955*	61,141	43,775	34,696	27,869	2,323	20,551	190,355	20,200 (1954–55)

Graduate Enrollment and Degrees

	Master's Degrees and Other Pre-Doctoral Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's and Other Pre-Doctoral Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)
1950*	8,150		7,425	15,575	4,865 (1949–50)	2,342		453	2,795	492 (1949–50)
1951*	6,878		9,574	16,452	5,134 (1950–51)	2,419		456	2,875	586 (1950–51)
1952*	7,422		9,996	17,418	4,132 (1951–52)	2,261		669	2,930	586 (1951–52)
1953*	8,084		10,321	18,405	3,726 (1952–53)	2,298		703	3,001	592 (1952–53)
1954*	8,296		8,776	17,072	4,130 (1953–54)	2,483		796	3,279	590 (1953–54)
1955*	9,439		8,968	18,407	4,444 (1954–55)	2,653		508	3,161	599 (1954–55)

	1940	1947	1948	1949	1950	1951	1952	1953	1954	1955
Total college enrollment in U. S.**	1,490,000	2,333,000	2,410,000	2,456,000	2,297,000	2,116,000	2,148,000	2,251,000	2,499,750	2,720,929
Engineering enrollment in U. S.**	113,497	244,390	241,554	198,266*	161,324*	147,694*	158,518*	171,832*	187,454*	211,923*
Per cent engineering to total	7.6%	10.5%	10.0%	8.0%*	7.0%*	7.0%*	7.4%*	7.6%*	7.5%*	7.8%*

* Includes only ECPD accredited institutions. ** Includes outlying parts.

Summary of Undergraduate Enrollments and Bachelor's or First Professional Degrees in Engineering in the United States, Outlying Parts, and Canada, by Curriculum: 1955

Engineering Curriculum	No. of Schools[1]	Enrollment										First Engineering Degrees 1954-55	
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
										Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Schools accredited by ECPD:													
Aeronautical	47	1,979	1,818	1,213	1,016	40	28	42	190	6,294	32	625	3
Agricultural	39	577	463	374	315	9	—	19	1	1,758	—	236	—
Architectural	24	501	444	379	374	30	20	15	45	1,768	40	251	2
Ceramic	14	208	197	145	113	5	—	8	—	660	16	86	—
Chemical	106	4,590	4,270	3,499	2,771	134	146	97	591	15,924	174	1,939	13
Civil	136	6,166	5,950	5,097	4,555	171	201	158	1,486	23,682	102	3,551	6
Electrical	136	12,173	12,374	9,789	6,950	203	325	368	3,653	45,712	123	4,487	13
Engineering Mechanics	3	—	31	29	16	—	—	1	—	75	2	10	—
Engineering Physics	27	311	453	305	291	34	2	7	23	1,406	20	197	3
General Engineering	24	1,244	859	753	592	2	—	9	637	4,072	24	573	—
Geological	25	357	425	315	275	5	—	2	1	1,378	2	181	—
Geophysical	5	87	75	45	22	—	—	1	—	229	1	25	—
Industrial[2]	63	966	1,341	1,526	1,615	82	49	53	359	5,967	24	1,170	4
Mechanical	132	9,795	10,040	8,716	6,853	338	334	288	3,327	39,574	117	5,240	8
Metallurgical	48	538	619	638	573	19	16	9	197	2,600	9	436	—
Mining	31	343	299	267	253	16	—	3	5	1,186	—	183	—
Naval Arch. & Marine	4	34	62	44	42	—	—	3	—	184	1	43	—
Petroleum	22	1,032	1,125	965	726	38	—	28	116	4,022	8	449	1
Sanitary	4	3	3	5	20	—	—	2	—	33	—	12	1
Textile	5	205	157	123	122	—	—	10	—	614	3	81	—
Unclassified	94	19,522	2,353	156	59	—	10	210	8,469	30,542	237	44	—
Other	40	510	417	313	316	65	1	82	36	1,716	24	324	3
Total ECPD	149	61,141	43,775	34,696	27,869	1,191	1,132	1,415	19,136	189,396	959	20,143	57
Other U. S. Schools	67	11,684	7,066	4,681	3,431	167	318	532	3,214	30,978	115	2,384	5
All U. S. Schools	216	72,825	50,841	39,377	31,300	1,358	1,450	1,947	22,350	220,374	1,074	22,527	62
Canadian Schools	10	2,662	2,042	1,524	1,587	281	—	1	—	8,073	24	1,143	1
Grand Total (U. S. and Canada)	226	75,487	52,883	40,901	32,887	1,639	1,450	1,948	22,350	228,447	1,098	23,670	63

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Includes administrative engineering, management engineering, etc.

Undergraduate Engineering Enrollment as of October 3, 1955, and First Engineering Degrees Conferred in 1954–55, by School

Institution	Enrollment										First Engineering Degrees 1954–55	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ECPD accredited schools:												
Alabama												
Ala. Poly.	1,008	653	454	320	—	—	4	—	2,431	8	232	—
Univ. Ala.	449	281	215	148	—	—	1	865	1,942	17	81	1
Arizona												
Univ. Ariz.	487	332	268	188	—	—	10	21	1,300	6	120	2
Arkansas												
Univ. Ark.	295	271	178	169	—	—	1	—	911	3	79	—
California												
Calif. Tech.	178	91	86	79	—	—	—	—	434	—	61	—
Santa Clara	90	93	79	51	—	—	—	—	313	—	44	—
Stanford	347	297	273	266	—	—	—	—	1,179	4	144	—
U. S. Naval PG Sch.	—	—	127	160	—	—	—	—	287	—	131	2
Univ. Calif.[1]	536	525	951	808	—	—	26	—	2,825	21	490	—
Univ. Southern Calif.	145	153	360	272	—	—	194	253	1,372	5	202	2
Colorado												
Colo. A. & M.	286	157	102	80	—	—	—	—	624	1	63	—
Colo. Mines	339	299	213	165	—	—	—	—	1,014	2	132	—
Univ. Colo.	726	549	388	324	44	—	2	824	2,837	20	220	2
Univ. Denver	102	87	60	48	—	1	15	10	320	3	44	—
Connecticut												
U. S. Coast Guard	205	115	88	89	—	—	—	—	497	—	76	—
Univ. Conn.	567	324	168	146	—	—	46	—	1,248	3	87	2
Yale Univ.	—	199	206	199	17	—	5	—	626	—	172	—
Delaware												
Univ. Delaware	182	129	136	82	—	—	3	—	526	6	63	—
Florida												
Univ. Florida	835	426	282	240	—	99	—	—	1,880	2	183	1
Georgia												
Ga. Tech.	1,396	1,001	648	562	—	—	4	—	3,594	17	442	—

Idaho												
Univ. Idaho	288	192	152	132	—	—	—	—	763	1	82	1
Illinois												
Bradley	262	110	65	61	—	—	2	100	599	1	60	—
Ill. Inst. Tech.	420	383	333	251	—	6	27	3,937	5,257	100	276	1
Northwestern	247	181	138	128	—	104	14	91	897	6	114	1
Univ. Ill.	1,865	1,324	1,009	1,014	—	—	55	—	5,240	27	530	—
Indiana												
Notre Dame	440	273	286	178	—	—	2	—	1,179	—	180	—
Purdue	1,709	1,360	1,164	1,028	—	—	6	—	5,227	40	758	2
Rose Poly	146	112	93	80	—	—	4	—	435	—	54	—
Iowa												
Iowa St. Coll.	1,257	836	594	387	—	—	10	—	3,071	13	263	—
St. Univ. Iowa	227	159	136	84	—	—	—	—	604	2	51	—
Kansas												
Kan. St. Coll.	454	387	289	191	—	—	67	—	1,382	6	128	—
Kan. Univ.	488	404	371	304	—	—	6	—	1,560	13	133	1
Mun. Univ. Wichita	481[2]	210[2]	133[2]	79[2]	—	—	21	—	917	7	25	—
Kentucky												
Univ. Kentucky	537	472	240	172	—	—	18	—	1,434	5	139	—
Univ. Louisville	195	119	106	81	67	—	1	—	567	2	60	—
Louisiana												
La. Poly.	427	214	148	107	—	—	7	—	902	1	67	1
La. St. Univ.	951	350	403	309	—	—	—	—	2,001	12	196	1
Tulane	228	147	85	65	—	—	—	—	524	1	44	—
Maine												
Univ. of Maine	431	274	213	152	16	—	6	—	1,086	6	109	—
Maryland												
Johns Hopkins	126	141	124	104	—	—	3	529	1,027	—	156	—
Univ. Maryland	587	425	184	146	—	35	32	—	1,402	7	97	—
Massachusetts												
Harvard	—	86	50	27	2	—	—	—	165	—	25	—
Lowell Tech.	276	152	82	44	—	—	22	—	576	—	38	—
Mass. Inst. Tech.	667	699	664	695	—	—	—	—	2,708	17	553	4
Northeastern	790	589	533	358	—	243	—	—	2,493	20	279	—
Tufts Univ.	192	151	144	120	—	—	—	—	603	4	93	1
Univ. Mass.	295	219	167	111	—	—	—	—	782	10	75	—
Worcester	296	244	180	133	—	—	—	—	853	—	124	—
Michigan												
Detroit Univ.	501	278	294	186	—	165	51	312	1,781	6	171	—
Mich. M. & T.	599	509	345	274	—	—	—	—	1,717	10	177	—
Mich. St. Univ.	757	531	444	366	—	—	11	14	2,123	—	220	1
Univ. Mich.	707	934	523	447	—	—	67	—	2,644	34	308	2
Wayne Univ.	566	397	282	229	89	—	4	—	1,549	18	97	1
Minnesota												
Univ. Minn.	879	603	587	406	287	—	102	—	2,852	12	306	1
Mississippi												
Miss. St. Coll.	474	333	241	164	—	—	—	—	1,210	2	98	—
Univ. Miss.	103	52	40	37	—	—	1	—	231	2	35	—

[1] Includes data for the Los Angeles and Berkeley campuses which were formerly reported separately.
[2] Includes Evening students.

Undergraduate Engineering Enrollment as of October 3, 1955—*Continued*

Institution	Enrollment										First Engineering Degrees 1954–55	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Missouri												
Mo. Mines	582	446	462	270	—	—	—	—	1,758	2	204	—
Mo. Univ.	510	326	232	198	—	—	—	—	1,258	8	94	—
St. Louis Univ.	268	170	66	95	—	—	12	3	613	1	104	2
Wash. Univ. (St. L.)	362	257	199	195	—	—	—	—	1,007	6	102	1
Montana												
Mont. Mines	105	66	39	34	—	—	—	—	244	—	26	—
Mont. St. Coll.	395	259	115	131	—	—	—	—	897	3	82	1
Nebraska												
Univ. Nebraska	387	403	197	139	—	—	—	—	1,122	4	104	—
Nevada												
Univ. Nevada	183	88	87	45	—	—	—	—	398	5	32	—
New Hampshire												
Dartmouth	155	102	43	36	24	—	—	—	360	—	26	—
Univ. New Hamp.	196	170	123	87	—	—	12	—	585	3	51	—
New Jersey												
Newark	406	389	354	241	—	—	—	1,195	2,566	19	256	4
Princeton	168	149	119	121	—	—	—	—	557	—	133	—
Rutgers	229	141	104	84	—	—	1	—	554	5	73	—
Stevens	363	239	184	162	—	—	—	—	948	—	128	—
New Mexico												
N. Mex. A. & M.	296	194	137	61	—	—	183	—	866	5	37	1
N. Mex. Univ.	310	193	137	82	—	—	—	—	714	8	79	—
New York												
Alfred	94	66	45	47	—	—	6	—	251	7	30	—
Brooklyn Poly	393	455	366	330	—	—	—	1,782	3,326	—	417	1
City Coll. of N. Y.	1,443	815	696	649	—	—	—	1,274	4,841	36	327	1
Clarkson	358	249	178	140	—	—	—	—	925	—	123	—
Columbia	—	—	207	133	—	—	—	—	337	3	108	2
Cooper Union	105	108	70	69	—	—	—	398	738	12	109	—
Cornell	546	444	339	247	217	14	—	—	1,793	14	236	—
Manhattan	307	321	230	197	—	—	4	—	1,059	—	137	—
N. Y. Univ.	322	272	297	256	—	—	16	966	2,119	10	362	—
Pratt	139	106	65	44	—	—	—	—	350	4	28	1
Rensselaer	758	590	583	459	—	—	1	56	2,447	—	444	—
Rochester	112	77	58	46	—	—	—	—	288	5	35	1
Syracuse	231	145	125	99	—	—	—	—	597	3	89	—
Union Coll.	127	99	73	52	—	—	3	79	422	11	36	—
Webb	20	15	16	10	—	—	—	—	61	—	16	—

North Carolina												
Duke Univ.	155	150	99	85	—	—	5	—	494	—	68	—
N. C. St. Coll.	1,036	678	441	349	16	—	—	—	2,514	6	220	—
North Dakota												
N. Dak. Ag. Coll.	311	190	168	123	—	—	—	—	791	1	77	—
N. Dak. Univ.	242	170	108	70	—	—	—	—	588	2	51	—
Ohio												
Akron	210	94	52	40	—	32	2	40	466	4	24	1
Case Inst.	395	263	282	248	—	—	12	18	1,217	1	180	—
Cincinnati	447	307	296	197	—	161	—	2,029	3,431	6	191	—
Fenn Coll.	225	74	58	9	—	41	3	867	1,275	2	85	2
Ohio No. Univ.	82	39	27	19	—	—	3	—	170	—	15	—
Ohio St. Univ.	1,076	650	389	274	258	—	34	141	2,814	8	192	—
Ohio Univ.	332	265	150	87	—	—	—	—	833	1	66	—
Toledo	247	152	97	80	—	—	52	401	1,026	3	58	—
Univ. Dayton	345	106	78	61	—	—	12	302	895	9	40	—
Youngstown	328	161	109	59	—	—	—	552	1,200	9	23	—
Oklahoma												
Okla. A. & M.	688	479	431	431	—	—	—	—	2,020	9	173	—
Okla. Univ.	810	676	516	434	2	—	—	—	2,438	—	236	—
Tulsa	204	140	105	67	—	—	12	103	625	6	77	—
Oregon												
Oregon St. Coll.	566	300	228	156	—	—	—	—	1,246	4	125	—
Pennsylvania												
Bucknell	152	91	65	65	1	—	2	—	373	3	34	—
Carnegie	322	313	278	263	—	—	12	561	1,743	6	244	1
Drexel	465	534	320	229	—	192	4	413	2,143	14	467	1
Lafayette	216	137	145	114	—	—	—	145	757	—	85	—
Lehigh	496	432	358	322	—	—	—	—	1,608	—	248	—
Pa. St. Univ.	1,166	784	712	673	12	—	—	—	3,331	16	412	2
Pittsburgh	531	449	358	278	—	—	—	531	2,140	7	220	—
Swarthmore	24	25	28	20	—	—	1	—	96	2	20	—
Univ. Pa.	174	135	96	93	—	—	—	—	496	2	50	—
Villanova	314	239	169	101	17	—	35	—	875	—	72	—
Rhode Island												
Brown	111	82	47	41	8	—	—	—	287	2	27	—
R. I. Univ.	218	177	122	78	—	—	16	—	611	—	68	—
South Carolina												
Citadel	298	131	77	76	—	—	—	—	582	—	58	—
Clemson	689	367	192	164	—	—	—	—	1,410	2	143	—
S. C. Univ.	367	239	156	98	—	—	—	—	857	3	65	1
South Dakota												
S. Dak. Mines	274	145	138	133	—	—	—	—	687	3	52	—
S. Dak. St. Coll.	321	206	123	77	—	—	3	—	726	4	37	—
Tennessee												
Univ. Tenn.	508	401	302	217	—	—	9	—	1,412	25	124	—
Vanderbilt	222	170	127	118	—	—	—	—	627	10	89	1

Undergraduate Engineering Enrollment as of October 3, 1955—*Continued*

Institution	Enrollment										First Engineering Degrees 1954–55	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Texas												
Tex. A. & M.	1,168	594	470	521	23	—	10	—	2,786	—	366	—
Rice	234	205	102	80	66	—	—	—	683	1	51	—
Southern Meth.	216	112	108	76	—	39	21	—	570	2	41	—
Tex. Coll. A. & I.	177	151	80	36	—	—	—	—	444	—	31	—
Tex. Tech. Coll.	635	435	331	239	—	—	—	—	1,638	2	131	—
Tex. Western	247	135	70	51	—	—	—	209	708	4	25	—
Tex. Univ.	871	840	878	563	—	—	—	—	3,132	20	225	—
Utah												
Utah St. Ag. Coll.	164	135	87	82	—	—	—	—	468	—	43	—
Univ. Utah	231	214	182	244	—	—	—	—	871	—	103	—
Vermont												
Norwich	105	80	56	41	—	—	—	—	282	—	43	—
Univ. Vermont	163	99	79	52	—	—	—	—	391	2	35	—
Virginia												
Va. Mil. Inst.	164	89	81	87	—	—	—	—	421	—	109	—
Va. Poly.	1,137	722	450	335	—	—	24	—	2,652	16	182	—
Va. Univ.	230	158	143	112	—	—	4	—	645	2	53	—
Washington												
Univ. Wash.	698	455	400	351	11	—	—	—	1,905	10	271	—
Wash. St. Coll.	297	249	188	136	14	—	—	—	875	9	85	1
West Virginia												
W. Va. Univ.	258	332	240	158	—	—	2	—	987	3	92	1
Wisconsin												
Marquette	325	259	219	208	—	—	—	—	1,003	8	123	—
Univ. Wisc.	1,364	821	575	411	—	—	26	76	3,256	17	249	1
Wyoming												
Univ. Wyo.	216	151	99	107	—	—	16	—	587	2	83	—
District of Columbia												
Catholic Univ.	103	42	33	62	—	—	7	39	286	—	53	—
Geo. Wash. Univ.	242	163	161	65	—	—	—	—	623	8	50	—
Howard Univ.	188	64	48	28	—	—	—	—	322	6	19	—
Alaska												
Univ. Alaska	65	24	12	11	—	—	—	—	112	—	7	—
Hawaii												
Univ. Hawaii	165	109	87	59	—	—	—	—	420	—	42	—
Total ECPD Schools	61,141	43,775	34,696	27,869	1,191	1,132	1,415	19,136	189,396	959	20,143	57

Summary of Graduate Enrollment and Degrees in Engineering in the United States, Outlying Parts, and Canada, by Curriculum: 1955

Engineering Curriculum	No. of Schools[1]	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1954–55		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[2]				Post-Grad. Degrees[2] in Eng'g 1954–55		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1954–55	
		Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
				Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
ECPD accredited schools:																			
Aeronautical	38	393	345	733	5	180	2	27	1	27	1	22	—	128	39	165	2	23	—
Agricultural	29	128	—	128	—	68	—	—	—	—	—	—	—	36	—	36	—	7	—
Architectural	10	15	—	15	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Ceramic	15	62	—	60	2	19	—	—	—	—	—	—	—	29	—	28	1	16	—
Chemical	90	1,098	759	1,849	8	454	1	—	3	3	—	14	—	525	79	602	2	139	—
Civil	97	1,333	709	2,037	5	676	3	13	—	13	—	10	—	199	22	220	1	29	—
Electrical	96	2,216	3,377	5,570	23	1,051	2	55	6	61	—	15	—	639	188	827	—	141	—
Engineering Mechanics	29	177	69	244	2	74	—	—	—	—	—	2	—	90	19	109	—	22	—
Engineering Physics	10	67	17	84	—	42	—	—	—	—	—	—	—	63	—	63	—	14	—
General Engineering	13	305	200	503	2	86	—	—	—	—	—	—	—	86	—	86	—	16	—
Geological	14	121	—	119	2	20	—	—	—	—	—	—	—	21	1	22	—	—	—
Geophysical	3	24	—	24	—	6	—	—	—	—	—	—	—	9	—	9	—	1	—
Industrial[3]	44	770	884	1,652	2	361	1	—	—	—	—	—	—	50	52	101	1	9	—
Mechanical	96	1,503	1,557	3,043	17	738	1	29	2	31	—	11	—	324	60	382	2	79	—
Metallurgical	43	262	309	570	1	146	—	5	—	5	—	—	—	215	21	234	2	62	—
Mining	20	45	1	46	—	24	—	—	—	—	—	—	—	6	1	7	—	2	—
Naval Arch. & Marine	3	27	—	27	—	16	—	78	—	78	—	27	—	1	—	1	—	—	—
Petroleum	14	111	40	151	—	62	—	—	—	—	—	—	—	14	—	14	—	5	—
Sanitary	16	87	6	91	2	68	—	2	—	2	—	2	—	37	5	42	—	6	—
Textile	3	27	—	27	—	13	1	—	—	—	—	—	—	4	—	4	—	—	—
Unclassified	20	102	467	567	2	58	1	—	68	68	—	—	—	12	12	24	—	—	—
Other	35	349	148	493	4	150	1	8	—	8	—	2	—	165	9	173	1	28	—
Total ECPD	122	9,222	8,888	18,033	77	4,326	13	217	80	296	1	105	—	2,653	508	3,149	12	599	—
Other U. S. Schools	5	166	206	369	3	40	—	—	—	—	—	—	—	2	—	2	—	—	—
All U. S. Schools	127	9,388	9,094	18,402	80	4,366	13	217	80	296	1	105	—	2,655	508	3,151	12	599	—
Canadian schools	9	164	47	211	—	76	1	—	—	—	—	—	—	67	—	67	—	12	—
Grand Total (U. S. and Canada)	136	9,552	9,141	18,613	80	4,442	14	217	80	296	1	105	—	2,722	508	3,218	12	611	—

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Other engineering degrees requiring work beyond the master's degree, but less than the requirements for a doctor's degree.
[3] Includes administrative engineering, management engineering, etc.

Graduate Engineering Enrollment as of October 3, 1955, and Graduate Engineering Degrees Conferred in 1954–55, by School

Institution	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1954–55		Number Enrolled in Work for Post-Graduate Pre-Doctoral Degrees[1]				Post-Grad. Degrees[1] in Eng'g 1954–55		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1954–55	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited schools:																		
Alabama																		
Ala. Poly.	18	—	18	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Ala.	13	—	13	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona																		
Univ. Ariz.	102	94	195	1	3	—	2	—	2	—	—	—	6	—	6	—	—	—
Arkansas																		
Univ. Ark.	14	—	14	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
California																		
Calif. Tech.	109	—	108	1	67	—	29	—	28	1	32	—	53	—	53	—	21	—
Stanford	333	—	332	1	120	—	26	—	26	—	13	—	74	—	74	—	22	—
U. S. Naval PG Sch.	64	—	64	—	71	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Calif.	493	—	490	3	145	—	—	—	—	—	—	—	165	—	165	—	26	—
Univ. So. Calif.	468	125	592	1	109	—	5	—	5	—	1	—	33	—	33	—	—	—
Colorado																		
Colo. A. & M.	26	—	26	—	9	—	—	—	—	—	—	—	2	—	2	—	1	—
Colo. Mines	40	—	40	—	11	—	—	—	—	—	—	—	12	3	15	—	2	—
Univ. Colo.	57	92	149	—	30	—	—	—	—	—	1	—	9	—	8	1	1	—
Univ. Denver	1	15	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Connecticut																		
Univ. Conn.	18	184	202	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale Univ.	52	26	77	1	36	1	—	—	—	—	—	—	48	—	48	—	16	—
Delaware																		
Univ. Delaware	190	—	190	—	28	—	—	—	—	—	—	—	20	—	20	—	3	—
Florida																		
Univ. Florida	51	—	51	—	15	1	—	—	—	—	—	—	5	—	5	—	4	—
Georgia																		
Ga. Tech.	161	—	161	—	74	—	—	—	—	—	—	—	21	—	20	1	3	—
Idaho																		
Univ. Idaho	11	—	11	—	11	—	—	—	—	—	—	—	—	—	—	—	—	—

Illinois																		
Bradley	6	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ill. Inst. Tech.	69	293	361	1	62	—	—	—	—	—	—	—	14	81	94	1	16	—
Northwestern	75	74	148	1	36	—	—	1	1	—	—	—	49	—	49	—	9	—
Univ. Ill.	315	1	314	2	166	2	—	—	—	—	—	—	152	—	151	1	38	—
Indiana																		
Notre Dame	36	83	119	—	16	—	—	—	—	—	—	—	4	—	4	—	—	—
Purdue	330	—	329	1	153	1	—	—	—	—	—	—	107	—	107	—	29	—
Rose Poly	2	—	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Iowa																		
Iowa St. Coll.	105	—	105	—	35	—	—	—	—	—	—	—	51	—	51	—	14	—
St. Univ. Iowa	49	—	49	—	24	—	—	—	—	—	—	—	30	1	31	—	3	—
Kansas																		
Kan. St. Coll.	41	—	41	—	11	—	—	—	—	—	—	—	4	—	4	—	—	—
Kan. Univ.	34	98	132	—	8	—	—	—	—	—	—	—	7	—	7	—	—	—
Mun. Univ. Wichita	—	35	35	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky																		
Univ. Kentucky	26	—	26	—	16	—	—	—	—	—	—	—	3	—	3	—	—	—
Univ. Louisville	24	40	64	—	7	—	—	—	—	—	—	—	—	2	2	—	—	—
Louisiana																		
La. St. Univ.	86	—	85	1	32	—	—	—	—	—	—	—	11	—	11	—	2	—
Tulane	16	—	16	—	—	—	—	—	—	—	4	—	—	—	—	—	—	—
Maine																		
Univ. Maine	21	—	21	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland																		
Johns Hopkins	84	63	147	—	26	—	—	—	—	—	—	—	73	—	73	—	16	—
Univ. Maryland	186	—	186	—	22	—	8	—	8	—	—	—	52	—	52	—	2	—
Massachusetts																		
Harvard	81	—	81	—	69	—	—	—	—	—	3	—	102	—	102	—	20	—
Lowell Tech.	14	—	13	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech.	704	—	701	3	459	2	120	—	120	—	49	—	332	—	328	4	70	—
Northeastern	—	116	113	3	46	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Mass.	7	12	19	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester	27	—	27	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Michigan																		
Detroit Univ.	—	13	13	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Mich. M. & T.	15	—	15	—	21	—	3	—	3	—	—	—	—	—	—	—	—	—
Mich. St. Univ.	64	—	63	1	30	—	—	—	—	—	—	—	29	2	31	—	6	—
Univ. Mich.	361	6	367	—	212	1	8	—	8	—	2	—	148	—	148	—	35	—
Wayne Univ.	241	—	240	1	38	—	—	—	—	—	—	—	—	—	—	—	—	—
Minnesota																		
Univ. Minn.	233	44	276	1	65	—	—	3	3	—	—	—	125	—	125	—	14	—
Mississippi																		
Miss. St. Coll.	15	—	15	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Miss.	8	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Graduate Engineering Enrollment as of October 3, 1955—*Continued*

Institution	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1954–55		Number Enrolled in Work for Post-Graduate Pre-Doctoral Degrees[1]				Post-Grad. Degrees[1] in Eng'g 1954–55		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1954–55	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Missouri																		
Mo. Mines	37	—	37	—	9	—	—	—	—	—	—	—	3	—	3	—	4	—
Mo. Univ.	30	—	30	—	13	—	—	—	—	—	—	—	6	—	6	—	—	—
St. Louis Univ.	11	178	189	—	8	—	—	—	—	—	—	—	5	—	5	—	—	—
Wash. Univ. (St. L.)	134	—	132	2	17	—	—	—	—	—	—	—	31	—	30	1	7	—
Montana																		
Mont. Mines	3	—	3	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Mont. St. Coll.	20	—	20	—	6	—	—	—	—	—	—	—	1	—	1	—	—	—
Nebraska																		
Univ. Nebr.	13	—	13	—	6	—	—	—	—	—	—	—	6	—	6	—	—	—
New Hampshire																		
Univ. New Hamp.	3	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey																		
Newark	—	745	740	5	114	1	—	—	—	—	—	—	—	—	—	—	—	—
Princeton	84	—	84	—	50	—	—	—	—	—	—	—	30	—	30	—	5	—
Rutgers	22	96	118	—	21	—	3	4	7	—	—	—	1	—	1	—	—	—
Stevens	—	776	772	4	144	—	—	68	68	—	—	—	—	28	28	—	1	—
New Mexico																		
N. Mex. A. & M.	—	35	35	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Univ.	123	—	123	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—
New York																		
Alfred	15	—	15	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Poly.	44	1,118	1,159	3	136	—	—	—	—	—	—	—	13	151	164	—	17	—
City Coll. of N. Y.	—	346	346	—	43	—	—	—	—	—	—	—	—	—	—	—	—	—
Clarkson	4	—	4	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
Columbia	428	—	425	3	156	—	—	—	—	—	—	—	126	—	126	—	19	—
Cornell	111	—	110	1	31	—	12	—	12	—	—	—	67	—	67	—	17	—
N. Y. Univ.	23	589	608	4	186	2	—	—	—	—	—	—	—	130	130	—	7	—
Rensselaer	125	333	458	—	56	—	—	—	—	—	—	—	31	—	31	—	8	—

Rochester	55	—	55	—	4	—	—	4	4	—	—	—	2	—	2	—	—	—
Syracuse	48	379	423	4	28	—	—	—	—	—	—	—	17	20	37	—	2	—
Union Coll.	—	73	73	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Webb	12	—	12	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
North Carolina																		
N. C. St. Coll.	91	—	90	1	43	—	—	—	—	—	—	—	14	—	14	—	5	—
North Dakota																		
N. Dak. Ag. Coll.	16	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Dak. Univ.	11	—	11	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Ohio																		
Case Inst.	49	416	464	1	62	—	—	—	—	—	—	—	15	50	64	1	6	—
Cincinnati	12	225	237	—	3	—	—	—	—	—	—	—	9	—	9	—	2	—
Ohio St. Univ.	161	37	198	—	64	—	—	—	—	—	—	—	92	—	90	2	14	—
Toledo	2	40	42	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Oklahoma																		
Okla. A. & M.	99	—	99	—	26	—	—	—	—	—	—	—	10	—	10	—	2	—
Okla. Univ.	65	—	65	—	35	—	—	—	—	—	—	—	2	—	2	—	—	—
Tulsa	27	32	59	—	17	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon																		
Oregon St. Coll.	21	—	21	—	11	—	—	—	—	—	—	—	5	—	5	—	2	—
Pennsylvania																		
Bucknell	2	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Carnegie	75	123	197	1	45	—	—	—	—	—	—	—	47	—	47	—	16	—
Drexel	285	—	285	—	44	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	114	—	114	—	34	—	—	—	—	—	—	—	21	—	21	—	8	—
Pa. St. Univ.	120	—	120	—	54	1	—	—	—	—	—	—	85	—	85	—	18	—
Pittsburgh	14	319	333	—	49	—	—	—	—	—	—	—	3	40	43	—	5	—
Univ. Pa.	72	645	710	7	51	—	—	—	—	—	—	—	74	—	74	—	7	—
Villanova	—	14	14	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhode Island																		
Brown	9	11	9	11	2	—	—	—	—	—	—	—	8	—	8	—	—	—
R. I. Univ.	13	1	14	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
South Carolina																		
Clemson	11	—	11	—	4	—	1	—	1	—	—	—	—	—	—	—	—	—
South Dakota																		
S. Dak. Mines	5	—	5	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. St. Coll.	6	—	6	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee																		
Univ. Tenn.	131	—	131	—	21	—	—	—	—	—	—	—	10	—	10	—	2	—
Vanderbilt	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Texas																		
Tex. A. & M.	68	—	68	—	44	—	—	—	—	—	—	—	11	—	11	—	1	—
Rice	15	—	15	—	9	—	—	—	—	—	—	—	4	—	4	—	1	—
Southern Meth.	2	618	617	3	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Coll. A. & I.	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Tech. Coll.	5	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Univ.	133	—	132	1	47	—	—	—	—	—	—	—	47	—	47	—	15	—

Graduate Engineering Enrollment as of October 3, 1955—*Continued*

Institution	Number Enrolled in Work for the Master's Degree				Master's Degrees in Eng'g 1954–55		Number Enrolled in Work for Post-Graduate Pre-Doctoral Degrees[1]				Post-Grad. Degrees[1] in Eng'g 1954–55		Number Enrolled in Work for the Doctor's Degree				Doctor's Degrees in Eng'g 1954–55	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Utah																		
Utah St. Ag. Coll.	13	—	13	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Utah	74	—	74	—	16	—	—	—	—	—	—	—	—	—	—	—	7	—
Virginia																		
Va. Poly.	46	—	46	—	36	—	—	—	—	—	—	—	13	—	13	—	4	—
Va. Univ.	18	123	141	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—
Washington																		
Univ. Wash.	173	—	171	2	48	1	—	—	—	—	—	—	19	—	19	—	5	—
Wash. St. Coll.	13	—	13	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
West Virginia																		
W. Va. Univ.	15	—	15	—	6	—	—	—	—	—	—	—	9	—	9	—	2	—
Wisconsin																		
Univ. Wisc.	92	173	265	—	80	—	—	—	—	—	—	—	75	—	75	—	17	—
Wyoming																		
Univ. Wyo.	8	—	8	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Dist. of Columbia																		
Catholic Univ.	47	29	76	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Geo. Wash. Univ.	247	—	247	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Total ECPD Schools	9,222	8,888	18,033	77	4,326	13	217	80	296	1	105	—	2,653	508	3,149	12	599	—

[1] Other engineering degrees requiring work beyond the master's degree, but less than the requirements for a doctor's degree.

The Journal of ENGINEERING EDUCATION

March, 1956 *Table of Contents* Vol 46, No 7

Articles

Do You Know		528
Iowa State College—A Campus Introduction		531
Survey of Engineering Mechanics	G. Wallace Smith	536
Human Relations in Engineering	B. von H. Gilmer and H. W. Karn	544
On Teaching Design	Chesley J. Posey	547
Another Look at General Studies	Weller Embler	551
Mathematics Teacher in Engineering	F. Virginia Rohde	555
Sentence Length in Scientific Writing	Harry F. Arader	560
"Case Studies" in Materials Laboratory	P. F. Brandenburg	563
Volumetric Efficiency—Ambiguous Term	R. P. Bobco and A. L. Gosman	565

Departments

Graphic Science: Analysis—Synthesis—Communication		569
YET-itude: A Busman's Holiday	Harold A. Foecke	573
Summer Schools—Construction Education		578
Drawing and Graphic Science		570
Humanistic-Social		591
Teaching Positions Available 576	New Members	580

Reports

Mathematics in Engineering		585
Role of Physics in Engineering Education	AIP Committee	592

Notes

Location of Ames, Iowa	530	Revised ASTE Data Index	572
Electron Microscope Course	550	John Clayton Tracy	584
"JETS" for High Schools	559	Oak Ridge Institute	606
Motion and Time Study	568	Section Meetings	ix
Torgersen Honored	568	Membership Application	x

DO YOU KNOW . . . .

► . . . That in October I stuck my neck out and said one of the aims of the Editor and myself was to get each issue of the Journal to you in the proper month? Well, there were unanticipated troubles! But the worst is over and by May and June we should be on schedule. The goal hasn't been changed but achieving it has been delayed.

► . . . That two new standing committees have been appointed by President M. M. Boring as a result of the meeting of the Society Functions Committee, conferences with members of the General Council, and nine months of experience as president? One is a "top level" Supervisory and Planning Committee. With Thorndike Saville as Chairman, this group includes A. B. Bronwell, L. E. Grinter, S. C. Hollister, B. R. Teare, Jr., and E. A. Walker as members. The purpose of the committee is to look ahead and assist the officers in making future plans for the Society, not to concern itself with present day and every day problems, but to do some "blue sky" thinking and planning. The appointments are for two calendar years and the chairman is to report to the General Council and Executive Board at Annual Meetings.

The second new committee is the Policy Committee, whose function is to advise the President on all matters which he chooses to refer to it. The President of the Society is the Chairman, and the Secretary of the Society is the Secretary of the Committee, without vote. This committee is made up of members of the General Council, half serving one year and the remainder two.

You may ask about the need for these committees. The answer simply is that questions and problems are coming up so fast and are so involved that the President and Secretary of the Society need course and guidance.

► . . . That the increased pace of Society activities also is evidenced by the fact that four items needed to be submitted to the General Council for letter ballot in order to act rapidly and effectively—and in order to comply with the constitutional requirement that the General Council establishes policies? These actions will have to be affirmed at the June meeting of the General Council in order to have the decisions adequately entered in the records. Letter ballots also needed to be sent to the Executive Board on three occasions.

► . . . That at the November meeting of the Executive Board, Vice President F. C. Lindvall stressed the need for better communications with and between Sections and Divisions? The Board agreed that if Sections had liaison representation with Divisions it would be helpful, particularly with respect to the Relations With Industry and the Physics Divisions. The Physics Division requested such liaison. Consequently each Section was asked to appoint a liaison member for the two Divisions mentioned. Liaison with Physics is important. If you have doubts, refer to p. 753 of the June, 1955, JOURNAL and to the "Role of Physics in Engineering" report on page 592 of this issue.

The interest of industry in engineering education, the successful series of College-Industry Conferences, and the increased activity of the Relations With Industry Division in undertaking local programs of cooperation between industry and education also makes liaison with RWI important.

► . . . That at its November meeting the Executive Board voted to approve a budget of $40,000 for the ECRC study of the Research Needs in the Engineering Sciences? Dr. H. K. Work, Vice President of the Society, represents the Board in the solicitation of funds. The proposal has been prepared and submitted to the National Science Foundation for approval.

► . . . That ECRC will have two awards each year for outstanding research. One will be a gold medal (comparable to the Lamme Award) and the other $1000 in cash for a younger man (comparable to the Westinghouse Award)? The sponsors are, respectively, Bendix Aviation Corporation and McGraw-Hill Book Company. The first award of the gold medal will be this year, but the first cash award will be presented in 1957.

► . . . That the total amount of money requested by Division and Committee chairmen has now reached a total of over $1800? Because this amount is increasing so rapidly, because some Divisions want to charge separate dues, and because Sections and Divisions are submitting so few papers for publication in the JOURNAL OF ENGINEERING EDUCATION, the Executive Board requested Vice President L. J. Lassalle to compile the pertinent data for all Divisional publications and then refer the tabulation to the Publications Committee for recommendations. Some of the budgets and plans for publications imply competition with the JOURNAL. The Executive Board unanimously agreed that Divisional or Committee publications must not interfere or compete with the JOURNAL.

► . . . That the Executive Board, at the November meeting, was in full agreement that payment of Divisional dues could not be a requirement for Society membership nor a requirement for attendance at any meetings of the Society or of any of its Divisions?

► . . . That the YET Committee has requested that the sub-chairman for each Section (and a member of the national committee) be selected (elected or appointed) by the Section? The General Council at its November meeting voted that, starting with the year 1956–57, each Section select its own YET sub-chairman, informing the Secretary of the selection as soon as possible after July 1 of each year. Section officers please take note and see that appropriate action is taken before July 1, 1956. The YET Committee is supposedly pressing its membership drive again this year; each institution should have a YET working on this, particularly in related areas such as physics, mathematics, and English. It your representative active?

► . . . That the Summer School for YETs at which pedagogical techniques were to be stressed is not materializing? At its College-Industry conference in Milwaukee, the

Steering Committee of the Relations With Industry Division voted. "That individual companies which were interested in such a program be approached or, conversely, that companies interested contact President M. M. Boring." The plan as proposed was for industry to employ the YETs for the summer, but release them to attend a four-week seminar, the necessary expenses being paid by the employers. Only one "firm" commitment and one "possible interest" developed. The need for this type of training was recognized by all in attendance, but they believed such training was a college problem and that undertaking the plan would impair the hard-won programs now in operation for employment of college teachers.

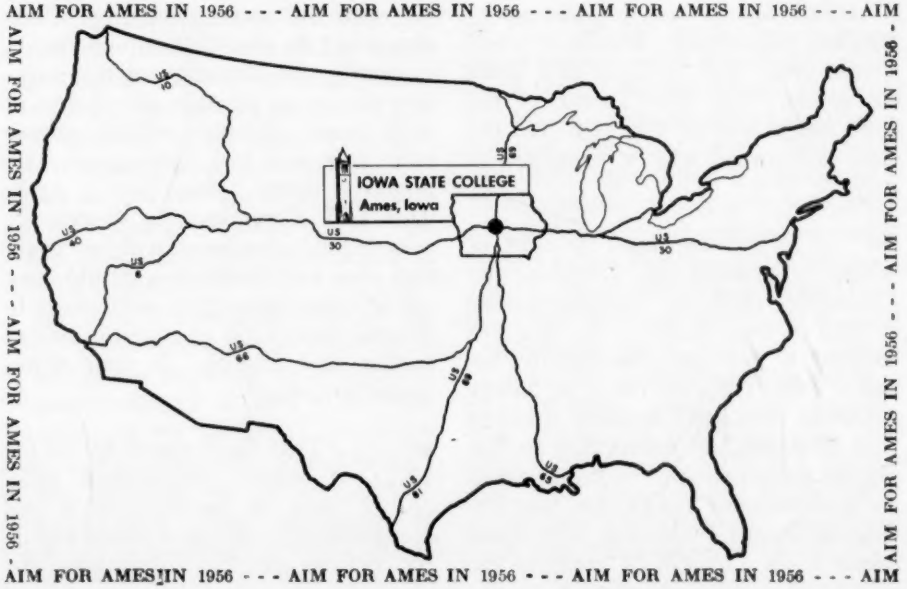
► . . . That the third dues notices have gone out—about 1100 of them? That is about one out of every eight members! For all who don't pay for 1955–1956 as a result of this "dunning," there will be no JOURNALS after June. For those who now owe for two years, the penalty is being dropped from membership by the General Council in June, unless payment is made by July 1. These are the provisions of the Constitution; see page 313 of the Yearbook.

► . . . That Engineers' Council for Professional Development at its meeting in October took an action which is extremely gratifying to the Society, as follows:

> "Voted that Council commend the efforts of the ASEE Committee on Ethics in promoting the interest of engineering faculties in the subject of ethics and stimulating the teaching of ethics to engineering students."

This is a handsome endorsement of what Dean C. J. Freund and his committee are trying to do.

W. LEIGHTON COLLINS,
Secretary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AIM FOR AMES IN 1956 - - - AIM FOR AMES IN 1956 - - - AIM FOR AMES IN 1956 - - - AIM
IOWA STATE COLLEGE
Ames, Iowa
US 10
US 80
US 30
US 6
US 66
US 91
US 50

GET ACQUAINTED WITH IOWA STATE!

In this issue, ASEE members and their families are given a preliminary view of Iowa State College's lovely campus, and begin their physical orientation for the Annual Meeting. On the following pages are an aerial photograph of the central buildings at Ames, keyed to facing close-ups of the focal points from which Society activities will radiate. It is hoped that with this combination ASEE visitors will have at least a few points of reference to find their way about and to recognize the starting blocks of their stay.

These might well begin with the Memorial Union Building, the hub of Society activities, in the center just north of eastwest highway 30. The Union lies directly between the men's residence halls (Friley-Hughes) two blocks to the west, and the women's residence group, about the same distance to the east, reserved for ASEE couples and families.

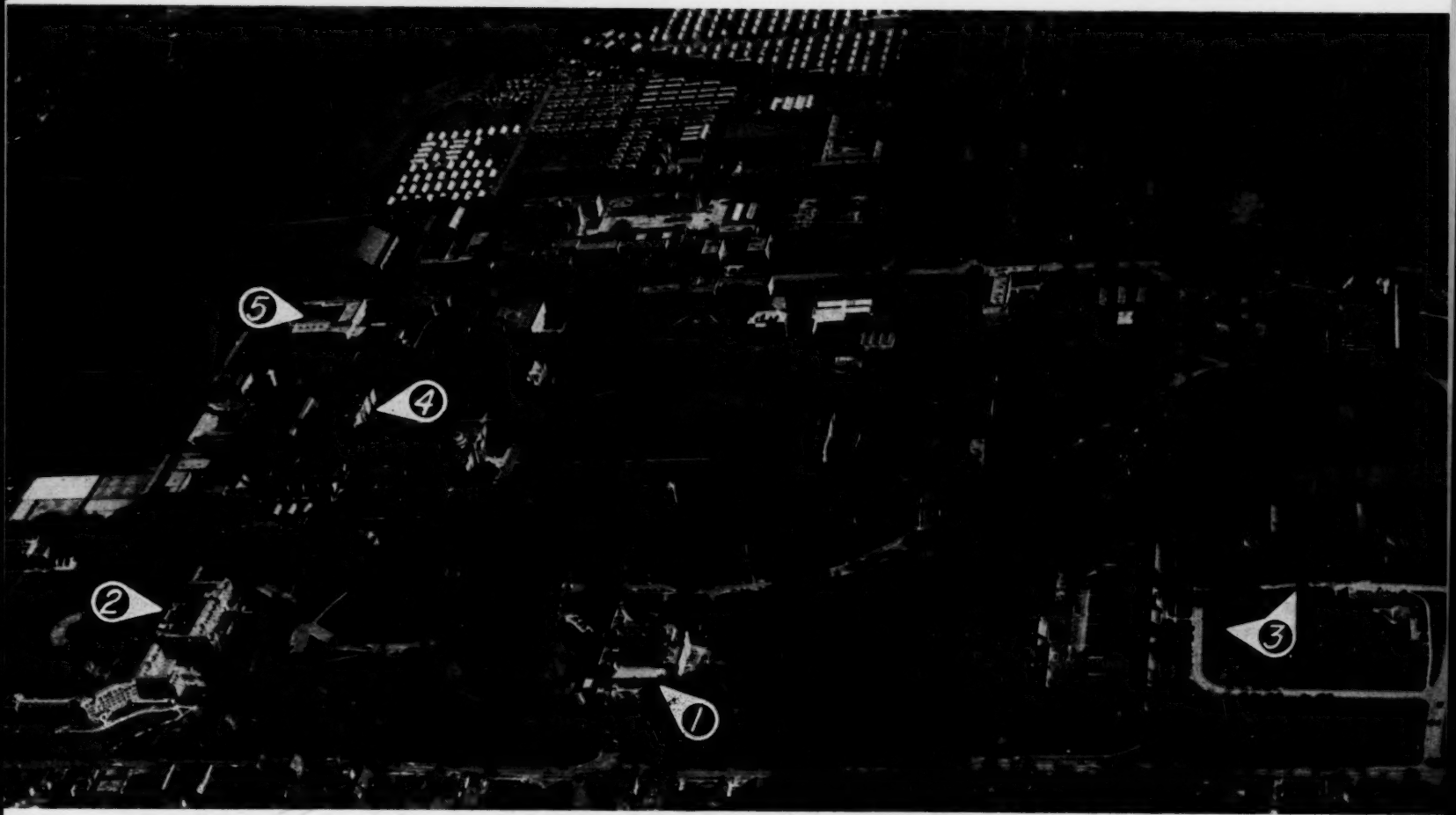
If you're a single man you'll take up your quarters in Friley-Hughes Hall, the home of 1,420 male students when filled to capacity during the regular college year. Its 640 rooms make it one of the largest student dormitories in the nation. Actually, Friley-Hughes is a succession of buildings, comfortably knit together into a harmonious structure which sprawls along more than two blocks of winding campus road and busy highway. Hughes Hall was erected in 1927, the first section of Friley Hall in 1939. Additions to Friley were built in 1942, 1951, and 1954, the final one serving to connect Friley and Hughes into the present mammoth structure. The combined hall bears the names of Dr. Raymond M. Hughes, president of Iowa State from 1927 to 1936, and Dr. Charles E. Friley, who guided the College from 1936 to 1953.

Meals will be served cafeteria style in the hall's west commons, seating 336 persons, and in six private dining rooms which can be arranged for groups varying in size from 24 to 120. The dining areas which members of the ASEE will use are part of the most recent construction program, and practically all are air-conditioned.

About four blocks east of Friley-Hughes Hall is the main group of women's residence halls, which will provide quarters for ASEE couples and families. Of eight halls clustered around a courtyard and semi-circular drive, seven will be reserved for those attending the Annual Meeting. Five units will accommodate 330 couples, and two will house 130 families. The first of the women's group was built in 1915, the last in 1940, and a large new unit is currently being constructed to complete the plan.

Midway between the men's and women's residence accommodations is the Memorial Union, which will serve as convention headquarters. The handsome limestone building was first occupied in 1928, but additions in 1936, 1939, 1949, and 1953 have greatly extended its size and usefulness. Still another expansion is planned within the next year. In the Union you'll find a spacious lobby, women's lounge, men's lounge, and a general television-watching lounge—all air-conditioned.

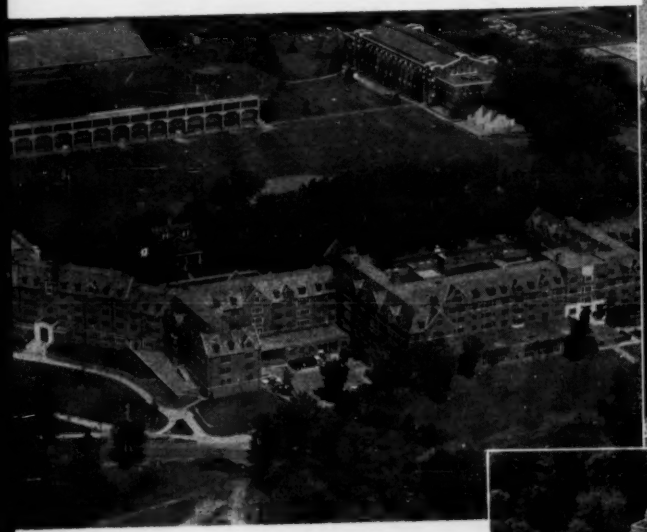
The Union is very proud of its food

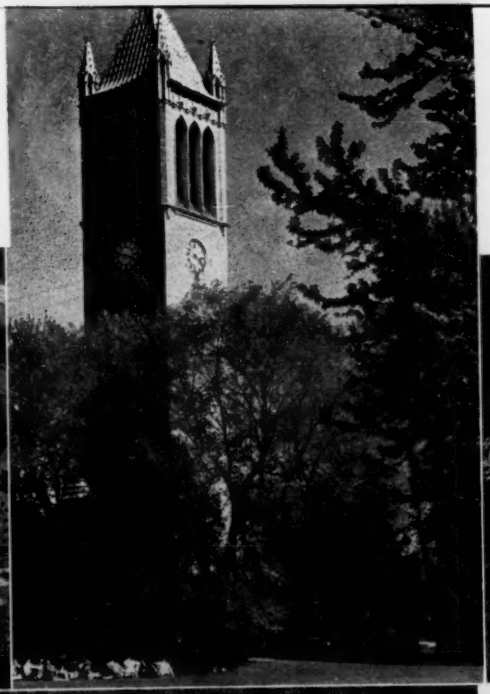


Aerial: General view of Iowa State College, looking north from Ames. East-west transcontinental highway, route 30, is in foreground. The focus of ASEE interest and activity will be (1) the Memorial Union. To left (2) are the men's residence halls, to right (3) the women's residence group. Building (4) is Marston Hall, headquarters of the Division of Engineering, and (5) is the Electrical Engineering Building.

Electrical Engineering Building.

Below—Men's Residence Halls, Friley-Hughes, assigned to ASEE bachelor visitors —the west pole of the campus east-west axis.





Left—The Stanton Memorial Carillon, landmark of the Ames campus, and the source of musical background for the convention.

Above—A unit of the Women's Residence Group, assigned to married couples and families of ASEE members.

←

(This view is from the northwest, with cars entering the access road from route 30 behind the building.)

Right—The Memorial Union of Iowa State College, ASEE Headquarters for the sixty-fourth Annual Meeting.

services, and offers attractive meals at moderate prices. The air-conditioned cafeteria and general commons room is a good place for breakfast, luncheon, or dinner, as well as an ideal spot for a cup of coffee and stimulating conversation between sessions. The air-conditioned Oak Room provides meals with table service. Some of the ASEE dinners and luncheons will be held in the Great Hall and South Ballroom of the Union. The many special meeting rooms will be scheduled for ASEE sessions throughout the convention.

To supplement the lounging areas, the "active" recreational facilities of the building include fourteen bowling alleys, a table tennis room, and a billiard room, all air-conditioned.

You'll be pleasantly surprised at Iowa State's uncrowded, uncluttered campus. Transcontinental Highway 30 marks its southern edge, along the residence hall area, but nowhere does a main highway cut through the College grounds. The prairie was broad when the first quadrangle was laid out, and even today the 845 acres of main campus and recreation areas are not filled.

Generally speaking, the college buildings are grouped around a large open rectangle which forms the central campus. Along the west side of the rectangle are most of the engineering facilities. Agriculture occupies the east side, with Home Economics, Science, and Veterinary Medicine along the north. Men's and women's residence groups, the Memorial Union, and the atheletic stadium form the south border.

As you stroll along pleasantly-shaded walks you'll hear the music of the Stanton Memorial Carillon. Housed in a 110-foot tower near the center of the campus, undisturbed by echoes, it is considered among the best musical instruments of its kind. Each morning hymns are played by the carillonneur just before 8 o'clock. A program of college songs, classical music, and selections written especially for the carillon is played at 1 o'clock in the afternoon. Visitors may climb the tower to the room in which the keyboard is located, and watch the carillonneur during his programs.

The first scientifically tuned chime of bells to leave Europe, the Iowa State group was imported from the John Taylor and Company foundry in Loughborough, England, and placed at Ames in 1899. A quarter of a century later, 26 more bells were acquired, changing the chime of ten bells to a carillon of 36. This spring another thirteen bells are to be added.

Perhaps you'll also want to investigate the College Library, which has placed special emphasis on the development of complete scientific and technical journal files for both basic and applied fields in the physical and biological sciences. The Library's holdings in these areas rank favorably with other important research collections of this country. As of June, 1955, the collections numbered 451,444 accessioned volumes of books; 8,311 serials, including 2,732 journals, are currently received.

Most of the library services are concentrated in the main Library Building to the west center of the campus, but special collections are maintained for engineering, architecture, economics and sociology, and animal husbandry. Each of these is located conveniently to serve the staff and students concerned.

In addition to the engineering buildings, the facilities for home

economics and agriculture deserve visits on the main campus. Beyond these, the Experiment Station, the Ames Laboratory of the Atomic Energy Commission, and the Institute for Atomic Research head the list of interesting technical possibilities for exploration. Resources nearby for both entertainment and exercise are available as well. Those who exhaust these early, however, are invited to visit (either for a stroll or for a few hours to play a round or two) the College golf course at the northwest corner of the campus. Rated as one of the best in the Midwest, the opening holes of the course can be seen at the upper left of the aerial scene.

Above—A fairway of the Iowa State College golf course;

Right—A cafeteria scene in the men's residence halls.

AIM FOR AMES

June 25 - 29

By Air - By Bus - By Rail - By Car

Remember — Reservation to Room

110 Marston Hall, Ames, Iowa

ASEE 64th ANNUAL MEETING

SURVEY OF INSTRUCTION IN ENGINEERING MECHANICS

G. WALLACE SMITH

Head, Department of Engineering Mechanics
North Carolina State College, Raleigh

Presented at Annual Meeting of ASEE
Mechanics Division, The Pennsylvania State University
June 23, 1955

All degree curricula in engineering usually require that an understanding be acquired of: (1) the types of motion that occur in solid or fluid bodies; (2) the forces that act upon or affect the motion, equilibrium, and stability of the materials used in engineering construction, design, or field operations; (3) the basic laws that govern the proportioning and selection of materials to resist effectively the action of forces or utilize forces to best advantage.

The courses generally included in engineering mechanics for an undergraduate curriculum are divided into four major topics, and are intended to integrate and amplify the ideas developed in earlier mathematics and physics courses. These topics are: statics, dynamics, fluid mechanics, and strength of materials, with fluid mechanics and materials testing laboratories. Each of these topics places emphasis on the development and theory of the basic concepts that an undergraduate student should acquire for further use in his particular curriculum. The courses of engineering mechanics have as an additional objective the development of analytical skills and insights required in the solution of engineering problems.

Although these subjects are generally considered to be fundamental, the extent to which they are included in the several engineering curricula seems to vary. Even a single subject, such as statics or dynamics, would be presented with a different degree of emphasis for different curricula in the same school. This variance of subject material and time allotted for its presentation was so interesting that a study was made to try to find the degree to which the engineering mechanics courses were included in the various curricula of a large number of schools that are recognized by the Engineers' Council for Professional Development.

The data used in this study were obtained by examining the curricula of the engineering schools as given in their catalogs for the session 1953–1954. The fourteen curricula selected for this study were those most generally offered and accredited by the ECPD. All of the data obtained were tabulated and then sent to the respective engineering schools with a request that they check the accuracy and supply any additional information then available.

Information was finally obtained from 122 schools for a total of 746

curricula, varying from very large to comparatively small enrollments. In some schools there were many different curricula, in others there were only a few, and in three schools only one. Some of the schools were on the standard four-year plan, some on a five-year plan, and others were following cooperative plan. Because most of the schools were on the semester system, the data given for the term system were adjusted to the equivalent time of the semester system.

The data as assembled were useful in making a number of analyses, but it was decided to restrict the results of this study to the summaries given in Tables I through III.

No attempt has been made to form any conclusions from this study. The prime motive has been to present the facts so that any school or curriculum could compare its mechanics requirements with those generally indicated in this article. Each reader may form conclusions, which may vary widely to fit the particular interests or needs of a school, curriculum, or location.

Making the study has been interesting, however, and it is hoped that the results will be informative and useful to others as well.

General Information

The electrical engineering curriculum is used as an example to explain the general information given in Table I.

a. 115 of the 122 schools studied offered a degree in Electrical Engineering, 113 of which were accredited by the ECPD; 88 of these schools were on the semester system.

b. This curriculum indicated that statics was most frequently scheduled in the second year, second semester, after there had been scheduled an average of 5.32 semester hours of calculus and 5.85 semester hours of physics. The average has been mentioned here, but the table also indicates the extremes. Averages will be indicated hereafter, but the extremes can always be found in the table.

c. All of the schools scheduled statics, with an average semester requirement of 2.74 semester hours.

d. 114, or all but one of the schools, scheduled dynamics with an average requirement of 2.72 semester hours. Sixteen of these schools, however, scheduled a one-semester course to include both statics and dynamics, with an average requirement of 4.12 semester hours.

e. 113, or all but two of the schools, scheduled strength of materials, with an average requirement of 3.27 semester-hours. Of these schools, 20 required a laboratory course as part of the semester-hour credit, and 51 schools gave a separate materials testing course with additional semester-hour credits.

f. 74 schools scheduled fluid mechanics, with an average requirement of 3.00 semester hours, and 30 of these schools included a laboratory with the course.

g. The average number of semester hours scheduled for all mechanics courses was 11.27 hours, or 7.62 per cent of the total semester hours required in an average electrical engineering curriculum.

The information furnished in Table I is quantitative; that is, it gives the amount of time scheduled or allotted to the respective mechanics subjects in relation to other topics and the total curriculum. Some phases of the mechanics courses cannot be put in tabular form, such as the quality of

TABLE I

SUMMARY OF DATA FOR BASIC ENGINEERING MECHANICS COURSES SCHEDULED IN A NUMBER OF ENGINEERING CURRICULA

122 Schools Included			Aeronautical	Agricultural	Architectural	Ceramic	Chemical	Civil	Electrical	Physics	Geological	Industrial	Mechanical	Metallurgical	Mining	Petroleum	Total All Curricula
Number of Curricula		Included in Analysis	46	32	25	14	94	118	115	18	18	60	116	43	28	19	746
		Accredited by ECPD	34	23	19	12	75	116	113	6	14	37	114	40	27	18	648
		Using Semester System	34	24	19	9	71	93	88	10	14	47	94	32	20	16	571
		Using Quarterly System	12	9	6	5	23	25	27	8	4	13	22	11	8	3	175
Semester Statics First Started		Earliest*	1–2	2–1	2–1	1–2	1–2	1–2	1–2	2–1	2–1	2–1	1–2	2–1	1–2	2–2	1–2
		Latest*	3–1	3–1	3–2	3–2	4–1	3–1	3–1	4–1	3–1	3–2	3–1	3–1	3–1	3–1	4–1
		Most Frequent*	2–2	2–2	2–2	3–1	2–2	2–2	2–2	2–2	3–1	2–2	2–2	2–2	3–1	3–1	2–2
Semester Hours Scheduled before Starting Statics	Calculus	No. Curricula and Least Hours†	1 2⅔	1 2⅔	5 3	1 0	4 0	10 0	11 0	2 3½	1 3	5 0	11 0	3 0	1 0	2 0	48 0
		No. Curricula and Most Hours†	1 14	2 10	1 10	1 13⅓	1 16	1 14	1 14	1 13½	1 13	1 13⅓	1 14	1 13⅓	1 13⅓	1 13⅓	3 14
		Average Hours	5.43	5.82	5.48	6.67	6.46	4.94	5.32	6.81	6.59	5.20	4.99	5.89	6.26	5.64	5.54
		No. Curricula with Average or More Hours	24	14	9	6	43	54	50	8	12	24	56	21	15	10	308
	Physics	No. Curricula and Least Hours†	1 2⅔	1 2⅔	1 0	1 3	4 0	16 0	15 0	1 0	1 3½	6 0	18 0	3 0	1 0	1 0	66 0
		No. Curricula and Most Hours†	1 15⅓	1 15⅓	5 10	2 12	1 16	1 15⅓	1 15⅓	1 15⅓	1 12	1 15⅓	1 14	4 12	3 12	1 12	1 16
		Average Hours	6.35	6.85	6.27	7.85	6.83	5.41	5.85	6.69	8.08	5.78	5.12	6.62	7.57	7.00	6.12
		No. Curricula with Average or More Hours	18	21	10	9	41	47	55	7	9	24	50	24	15	11	272

* The first number indicates the year offered, the second number the semester; Example 2–1, second year first semester.
† The numbers in upper left corner indicate the number of curricula, those in the lower right corner the number of hours; Example 2/10 two curricula of 10 hours each.

TABLE I—*Continued*

122 Schools Included		Aeronautical	Agricultural	Architectural	Ceramic	Chemical	Civil	Electrical	Physics	Geological	Industrial	Mechanical	Metallurgical	Mining	Petroleum	Total All Curricula
Statics	No. Curricula Requiring	46	32	25	14	94	118	115	18	18	60	116	43	28	19	746
	No. Curricula and Least Hours†	9 / 2	7 / 2	9 / 2	1 / 1½	1 / 1½	2 / 1½	1 / 1½	1 / 1½	1 / 1½	1 / 1½	1 / 1½	1 / 1½	1 / 1½	1 / 1½	4 / 1½
	No. Curricula and Most Hours†	1 / 5	3 / 3½	1 / 4	1 / 4	3 / 4	1 / 5	1 / 5	3 / 3½	1 / 4	1 / 4	1 / 5	3 / 4	1 / 4	1 / 4	4 / 5
	Average Hours	2.85	2.73	2.64	2.69	2.57	2.84	2.74	2.64	2.52	2.73	2.82	2.76	2.68	2.40	2.73
	No. Curricula with Average or More Hours	29	19	16	9	56	80	68	12	8	40	75	26	17	13	450
Dynamics	No. Curricula Requiring	46	29	13	7	45	115	114	14	12	57	116	31	24	15	638
	No. Curricula and Least Hours†	13 / 2	10 / 2	5 / 2	4 / 2	1 / 1	2 / 1½	1 / 1½	1 / 1½	1 / 1	1 / 1½	1 / 1½	1 / 1	1 / 1½	1 / 1½	3 / 1
	No. Curricula and Most Hours†	1 / 5	1 / 3½	1 / 3½	2 / 3	1 / 3½	1 / 5	1 / 5	1 / 3½	2 / 3	4 / 3½	1 / 5	15 / 3	9 / 3	7 / 3	4 / 5
	Average Hours	2.78	2.57	2.54	2.29	2.29	2.77	2.72	2.54	2.06	2.67	2.80	2.47	2.44	2.44	2.65
	No. Curricula with Average or More Hours	29	15	8	3	21	75	70	7	2	37	78	17	12	7	381
Statics and Dynamics in One Semester	No. Curricula Requiring	6	7	4	1	17	11	16	2	6	7	14	7	6	5	109
	No. Curricula and Least Hours†	3 / 4	3 / 4	4 / 4	1 / 4	5 / 3	2 / 3	3 / 3	1 / 3	1 / 3½	4 / 4	1 / 3	1 / 3½	1 / 3½	1 / 3½	10 / 3
	No. Curricula and Most Hours†	3 / 5	4 / 5	4 / 4	1 / 4	2 / 5	4 / 5	5 / 5	1 / 4	5 / 4	3 / 5	7 / 5	2 / 5	2 / 5	4 / 4	32 / 5
	Average Hours	4.50	4.43	4.00	4.00	3.78	4.18	4.12	3.50	3.89	4.42	4.43	4.19	4.22	3.87	4.14
	No. Curricula with Average or More Hours	3	3	4	1	11	4	5	1	5	3	7	2	2	4	55

† The numbers in upper left corner indicate the number of curricula, those in the lower right corner the number of hours; Example 2/10 two curricula of 10 hours each.

TABLE I—*Continued*

122 Schools Included		Aeronautical	Agricultural	Architectural	Ceramic	Chemical	Civil	Electrical	Physics	Geological	Industrial	Mechanical	Metallurgical	Mining	Petroleum	Total All Curricula
Strength of Materials	No. Curricula Requiring	46	32	25	14	93	118	113	13	17	59	116	42	28	18	734
	No. Curricula and Least Hours†	2 / 2	1 / 2	2 / 2	3 / 2	12 / 2	1 / 2	9 / 2	1 / 2	5 / 2	4 / 2	2 / 2	7 / 2	4 / 2	1 / 2	52 / 2
	No. Curricula and Most Hours†	3 / 6	1 / 6	1 / 6	1 / 4	2 / 5	2 / 7	2 / 6	1 / 5	4 / 4	1 / 6½	9 / 6	1 / 4¾	8 / 4	4 / 4	2 / 7
	Average Hours	3.80	3.45	3.49	2.93	3.12	3.99	3.27	3.25	3.06	3.51	3.81	3.12	3.17	3.17	3.49
	No. Curricula with Average or More Hours	24	12	11	11	27	71	41	5	5	28	61	17	11	5	284
	No. Curricula Having Lab. with Course	6	4	0	0	9	23	20	3	4	9	20	7	5	3	113
	No. Curricula with Separate Lab. Course	31	20	22	9	24	107	51	5	2	33	88	23	13	8	436
Fluid Mechanics	No. Curricula Requiring	32	28	3	0	3	118	74	4	16	31	110	9	22	17	467
	No. Curricula and Least Hours†	5 / 2	3 / 2¾	1 / 2	– / –	3 / 3	4 / 2	2 / 1½	1 / 2	5 / 2	1 / 1½	6 / 2	2 / 2	6 / 2	3 / 2	3 / 1½
	No. Curricula and Most Hours†	1 / 6½	1 / 4¾	1 / 4¾	– / –	3 / 3	2 / 6	1 / 6	3 / 3	1 / 4	6 / 4	2 / 6	1 / 4	4 / 4	4 / 4	1 / 6¾
	Average Hours	3.29	3.43	3.22	—	3.00	3.71	3.00	2.75	2.61	2.92	3.53	2.89	2.94	3.06	3.33
	No. Curricula with Average or More Hours	9	16	1	—	3	59	53	0	11	20	53	6	16	6	205
	No. Curricula Having Lab. with Course	11	21	1	—	—	87	30	0	4	12	58	3	8	5	240

† The numbers in upper left corner indicate the number of curricula, those in the lower right corner the number of hours; Example 2/10 two curricula of 10 hours each.

TABLE I—*Continued*

122 Schools Included		Aeronautical	Agricultural	Architectural	Ceramic	Chemical	Civil	Electrical	Physics	Geological	Industrial	Mechanical	Metallurgical	Mining	Petroleum	Total All Curricula
Total Semester Hours Scheduled	No. Curricula and Least Hours†	2 / 8	1 / 7½	1 / 5	1 / 4	1 / 3	1 / 10	4 / 6	1 / 2	1 / 5	1 / 4	2 / 9	1 / 5	1 / 5	1 / 3	1 / 2
	No. Curricula and Most Hours†	1 / 22	1 / 17	1 / 16½	1 / 11	1 / 12	3 / 21	3 / 22	1 / 12	1 / 14	1 / 16½	3 / 22	1 / 14	1 / 14	2 / 14	4 / 22
	Average Hours	12.53	12.41	9.33	7.69	7.23	14.56	11.27	7.89	9.46	11.01	13.92	8.97	10.61	10.75	11.37
	No. Curricula with Average or More Hours	24	18	10	5	37	63	57	9	9	31	64	26	13	12	378
Per Cent of Total Hours Required for Graduation	No. Curricula and Least Per Cent†	1 / 4.51	1 / 4.72	1 / 2.98	1 / 1.96	1 / 2.14	1 / 5.86	1 / 4.14	1 / 1.35	1 / 3.40	1 / 2.80	1 / 5.59	1 / 3.27	1 / 3.40	1 / 2.07	1 / 1.35
	No. Curricula and Most Per Cent†	1 / 17.19	1 / 12.50	1 / 11.57	1 / 7.33	1 / 8.33	1 / 16.41	1 / 17.19	1 / 8.45	1 / 9.46	1 / 10.68	1 / 17.19	1 / 11.11	1 / 9.44	1 / 10.00	3 / 17.19
	Average Per Cent	8.64	8.52	6.13	4.56	4.91	10.02	7.62	5.30	6.27	7.50	9.45	6.15	7.11	7.25	7.73
	No. Curricula with Average or More Per Cent	21	15	14	7	41	55	60	11	9	29	54	19	11	12	399

† The numbers in upper left corner indicate the number of curricula, those in the lower right corner the number of hours; Example 2/10 two curricula of 10 hours each.

instruction and the emphasis placed on various topics under a particular subject. Also, the exact amount of material covered in each course was difficult to determine from the brief descriptions given in the catalogs. However, certain additional information was available on the general requests for these subjects among the various curricula of the same school, and the relative type of course in demand.

Intensity of Courses

Table II has been assembled to indicate the relative intensity of mechanics courses in each curriculum. The following criteria were used for classifying the data. When "type" is referred to in the following explanation, the kind, intensity, or quality of course is in question.

1. When only one type of the same subject is offered by the school, it is classified as the strongest.

2. When more than one type of the same subject is offered by the school and all requires the same amount of time, each is considered to be as strong as the other.

3. When more than one type of the same subject is offered by the school and one type requires more or longer instruction, that type is considered the strongest, and the other types are tabulated as condensed courses.

4. This table also indicates the number of schools that do not require

TABLE II

SUMMARY OF RELATIVE INTENSITY OF MECHANICS COURSES IN EACH CURRICULA

Curricula	Statics			Dynamics			Strength of Materials			Materials Testing			Fluid Mechanics		
	Strongest	Condensed	Not Required	Strongest	Condensed	Not Required	Strongest	Condensed	Not Required	Strongest	Condensed	Not Required	Strongest	Condensed	Not Required
Aeronautical Engineering	42	4	0	43	3	0	42	4	0	33	3	10	21	12	13
Agricultural Engineering	24	8	0	21	8	3	23	9	0	17	5	10	24	3	5
Architectural Engineering	24	1	0	12	1	12	22	3	0	20	2	3	3	0	22
Ceramic Engineering	10	4	0	5	3	6	7	7	0	8	2	4	0	0	12
Chemical Engineering	73	21	0	28	19	47	50	42	2	22	8	64	2	2	90
Civil Engineering	114	4	0	108	7	3	116	2	0	118	0	0	117	1	0
Electrical Engineering	98	17	0	100	15	0	75	38	2	51	14	50	43	33	39
Physics	16	2	0	12	2	4	8	6	4	6	1	11	3	1	14
Geological Engineering	14	4	0	7	5	6	9	9	0	4	0	14	12	4	2
Industrial Engineering	53	7	0	49	8	3	42	17	1	34	4	22	18	15	27
Mechanical Engineering	108	8	0	110	6	0	104	12	0	91	9	16	87	23	6
Metallurgical Engineering	33	10	0	20	10	13	20	22	1	23	5	15	6	3	34
Mining Engineering	23	5	0	17	6	5	15	13	0	13	2	13	17	6	5
Petroleum Engineering	17	2	0	13	2	4	12	6	1	10	1	8	13	4	2

some of the mechanics courses in the respective curricula.

Numerous schools, both with large and small student enrollments, offer only one type of some subjects, and some even offer only one type of each mechanics course. Other schools offer varied types of courses for each subject.

Distribution of Courses

Table III has been assembled to indicate the distribution of mechanics courses in schools and curricula. Using dynamics as an illustration, this table shows:

a. 492 curricula have the strongest course.

b. 55 curricula offer statics and dynamics in one course, and no other courses include these subjects.

c. 59 curricula offer statics and dynamics in one course, in addition to stronger courses offered for these subjects.

d. 31 curricula offer a condensed or shorter course.

e. 109 curricula do not require dynamics.

f. 85 schools have one type of dynamics course; 32 schools have two types of dynamics courses.

g. 415 curricula have one type of dynamics course; 181 curricula have two types of dynamics courses.

TABLE III

SUMMARY OF THE DISTRIBUTION OF MECHANICS COURSES IN SCHOOLS AND CURRICULA BY SUBJECTS

Subject	Number of Curricula Having							Schools Having				Curricula Having			
	Strongest Course	Statics and Dynamics in One Course		Shorter or Condensed Course	Course Not Required	Total	Requiring Laboratory	1	2	3	4	1	2	3	4
		Only	Also					Type Courses in				Type Courses in			
Statics	599	55	59	33	—	746	—	90	28	4	—	538	170	38	—
Dynamics	492	55	59	31	109	746	—	85	32	4	1	415	181	35	6
Strength of Materials	538			193	15	746	103	67	55	—	—	377	354	—	—
Materials Testing	378			50	318	746	428	82	25	—	1	314	107	—	7
Fluid Mechanics	396			76	274	746	237	74	39	8	—	274	161	37	—

HUMAN RELATIONS IN THE ENGINEERING CURRICULUM

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We hear much these days about the pros and cons of "human relations training in industry" and as to "how our evolving technology is impelling the engineer, whether he wants to or not, to go in the direction of having to assume an executive role in American industry." If it is so vital to engineering-executive development, where can human relations training find a place in the undergraduate picture?

Those of us teaching non-technical subjects in engineering are faced with the problem of designing courses best suited to the needs of the engineer. In this article we wish to describe a basic psychology course, with emphasis on human relations, designed specifically to fit within the humanistic-social stem of the engineering curriculum at the Carnegie Institute of Technology.

Why a course in psychology for engineers? There are two cogent reasons. First, a majority of the graduates of engineering schools find themselves in positions of an administrative, supervisory, or executive character within a few years after graduation. There is no reason to expect any change on this score. Indeed, most engineering students do not want a change, if for no other reason than the fact that financial remuneration is highest among positions of this nature. Second, business and industry have to date been unable to solve many of their personnel problems. Apparently the psychological know-how necessary is at present lacking or at least is not being put into practice. Since many of the most pressing problems confronting the supervisor, administrator, and executive involve personnel relations, it is reasonable to equip the student in training for such jobs with all the psychological tools that will aid in the understanding of human relations situations.

How best a course in psychology for engineers? Proceeding on the assumption that engineers need a separate course in psychology, the problem might appear to be solved by simply requiring all students to take such a course sometime during their training. The solution is not so simple in view of the experience at Carnegie with the conventional psychology course. By "conventional" is meant the use of a standard psychology text and the presentation of illustrative and explanatory material through lectures and experimental demonstrations by the instructor.

This so-called conventional method, with its emphasis upon textbook content, has proven somewhat sterile. The typical engineering student shows little evidence of being able to adapt his textbook psychology to realistic problems of the type he will encounter in professional life. He does well enough on objective content

examinations and pays lip service to scientific psychology. When required to analyze a human relations problem and formulate a sound solution, however, it never occurs to him that his psychology has any relation, or else he states that an answer is impossible until an experiment can be conducted.

One student remarked that industry should cease operation for two years so that psychologists might conduct enough experiments to settle industry's human relations problems scientifically. A good point theoretically perhaps, but not a very practical one; and even then, the problem would still be one of using psychological findings as an *aid* to judgment, not as a substitute for it. In short, what the student fails to acquire from conventional courses is an interest in and ability to use psychological aids.

It has been suggested, therefore, that engineering students, and indeed all non-psychology majors, be taught a course in applied psychology instead of the regular introductory course. This does not appear to be a very satisfactory approach either. Leaping directly into applied psychology seems to create the impression that psychology is just a system of tricks, some clever scheme for getting people to do what they ordinarily do not want to do. Students feel that they are in a position to "use" psychology in the sense that the high pressure salesman and unscrupulous politician "uses" it, failing to appreciate that such persons no more "use" psychology than the boy who kicks a football "uses" physics. These observations point to the conclusion that what is needed is not a course in applied psychology, but instead a course in *appliable* psychology.

In an attempt to resolve the difficulties of both conventional and applied approaches, we have developed a three-credit, one-semester introductory course entitled "The Psychology of Human Relations." This course is taken during the junior year and is required of all engineering students. It stresses the *induction* of fundamental principles by the student, plus practice in the systematic application of these principles to a wide variety of human relations. The basic principles are carefully selected beforehand by the instructor, but are not presented to the student. Instead, the student is encouraged to induce these fundamentals from instances of human behavior that are comprehensible to him because of his previous experience. The student—not the instructor—is required to make the generalizations. Checking the hypotheses through deduction is the final stage in building up a set of basic principles for later use.

An example of the instance-induction procedure can be taken from the field of motivation. The student is asked why men work—or why men eat—or why certain people go to school—or why people rationalize. These questions generally yield workable answers which are couched in terms of the satisfaction of some want, need, or desire. The student quite readily generalizes that motives are the reasons for behaving and that these motives are varied and complex. With this background, and some opportunity to apply the generalization in specific situations, the student is in a position to see, among other things, the futility of dealing with all human behavior in terms of financial or monetary incentives.

Concurrent with the development of psychological principles, the student

is introduced to concrete human relations problems of varying complexity. These may deal with adjustments at home, in school, or in industry. Every attempt is made to use previously-derived principles in new and concrete cases. Apart from the induction of basic principles from instances, the solving of concrete problems by the student is the chief class activity. The problems are selected so that the student sees the necessity for first carefully determining the real problem at hand, and then planning his proposed course of action.

How effective has the course been in accomplishing its aims? As any teacher knows, it is most difficult to evaluate the effectiveness of teaching at the behavioral level as well as the verbal level. However, we do have some evidence that the methods used in the course, "Psychology of Human Relations," is the best approach yet tried at Carnegie in teaching a one-semester unit for engineering students. We believe the main goals of the course are being realized. Many Carnegie students take advanced elective courses in social psychology, industrial psychology, and the psychology of adjustment. Although these students do not have at hand a wide range of factual material from the basic psychology course, they do appear to have an appreciation of fundamental principles in the areas of emotion, motivation, learning, and adjustment.

This is indicated by the way in which they are able to handle realistic problems in the advanced undergraduate courses, by their analyses of the uses and limitations of psychological procedures and by the realization that many concepts developed under experimental conditions have application in real life situations.

On the more objective side, experimentally controlled studies have been made before and after the course to determine student attitudes toward dealing with human problems. Significant favorable gains were evidenced from those students having taken the course in comparison with control groups who had not.

There is another type of evidence that the course has been "sold" which we believe to be of some importance —the engineering faculty feels the course is meeting a vital need of their students. Whether this attitude is due to the effectiveness of the course, or to the participation of key engineering faculty members in helping establish the course, or to both, is unimportant. It has given us a favorable environment in which to work.

Over the past seven years in which the course has been evolving, the Provost and Deans concerned have made available opportunities for the psychology staff and engineering faculty to work closely together on various educational problems. The engineering faculty visits our classes in psychology and we visit some of those in engineering. We exchange ideas on teaching methodology. Let no one overlook the advantages of this kind of immediate human relations in teaching psychology to another professional group!

ON TEACHING DESIGN

With Special Application to Civil Engineering

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A paper presented at the meeting of the North Midwest Section, ASEE, held at South Dakota State College, Brookings, November 4–5, 1955

The traditional civil engineering course has long been criticized because it does not produce enough graduates capable of doing design work. Few are trusted with responsibility for design until they have had years of experience, and even then not until they have been cautiously tested on minor projects or on those where the opportunity exists for a careful review of their work. Many fall by the wayside.

A common opinion is that one is born with design sense or is not, and that the years of sub-professional practice are not so much for education as for discovering and winnowing out those unsuited for this type of work. An employer of young graduates who hopes to obtain designers first tests them on routine computations, drafting, and analysis. These are basic skills all graduates are supposed to have acquired in school, and indeed most of them have.

When opportunity presents, the young graduate who has proved himself able to do the routine work satisfactorily is given some real design work to do, and his product is carefully weighed. He is seldom allowed many failures. In spite of the fact that considerable attention is given to "design" in the civil engineering curriculum, it is at precisely this point that too many of our graduates reach their limit.

I believe that this is true because we engineering educators have not, in the main, understood what sort of teaching procedure is necessary to train designers, and except in rare instances have not been giving our students the type of training they really need. We have thought of design as being the particular sequence of computations one goes through in order to proportion structural members so that they will conform with the specifications or building code. In the standard textbooks, the treatment of design problems is limited almost entirely to details of typical structures, methods of analysis, special computational procedures for determining sizes, and codes or specifications. Now I do not say that this knowledge is useless. I merely say that such study *per se* is not effective in producing designers.

In order to determine how students should be trained to become designers,

let us consider what the successful designer does. He must:

(1) foresee every final demand that a given structure will be required to meet.
(2) be able to conceive, in fairly complete detail, alternative plans that will meet the requirements economically.
(3) determine which plan is most satisfactory and economical.
(4) be able to complete and set down the finally selected plan clearly enough so that the draftsman can draw it and the contractor can build it.

Our present teaching methods give some training to develop the student's ability in communicating his ideas, and in analytical methods. The latter are necessary aids to the judgment in selecting the most feasible plan, but they give practically no opportunity to develop the abilities needed for the first step of the designer's work, and little real practice in developing the kind of judgment designers need for the third step. Even the best of our graduates are likely to overlook some minor but important function of the structure, or to prepare only one design and defend it stubbornly against suggested alternatives.

There is a way of teaching design, however, that *does* foster real development along all these lines. It benefits the students who have a natural inclination towards design much more than does the old type of instruction. Instead of starting by teaching the use of the specialized tools in the designer's workbag, the new method plunges directly into problems which involve the whole range of design activity. Problems are simple at first. As they become more complex, the use of any specialized tools which may seem to be needed is explained by the instructor.

The student may first be asked to design a garage, one for his own use that he may wish to build after he graduates and settles down in a new home. The result asked for is a set of plans and specifications that would tell a carpenter foreman what is desired. When his design is completed, each student presents it orally to the other members of the class, who are encouraged to ask questions and to criticize as a board of review. Often questions are asked that show up serious defects. If not, the instructor should bring them out tactfully by such questions as "Are you sure the beam over the double door is strong enough, and won't deflect too far?"

The question and answer period is important, and it calls for the greatest skill on the part of the instructor to create the right psychological atmosphere for free class discussion. Amazing individual differences come to light, with some of those who evidence good design sense showing serious defects in the way of too little or too much self-confidence. By the end of the course, though, those who have real design talent will know how to defend their ideas. They have learned to compromise judiciously and quickly when a valid criticism is made.

By the end of the course, too, those who have little talent for design will be thoroughly convinced that they should seek some other type of work. Under the traditional type of instruction, these same individuals might be in a far worse position. If they were able to follow successfully the typical designs worked out in the textbook, they might have earned a high grade

in the course and a false idea of their ability as designers, an idea that might easily doom them to many years of frustration. In, on the other hand, they received a low grade, they might or might not be convinced that they could not design. It should also be pointed out that in the traditional type of course, some students who receive a low grade might even have considerable design talent. This is especially true when in his grading the instructor puts too much emphasis on superficial aspects of assignments.

In the new type of course no text is used, but a great deal of thought is given to the selection of suitable problems graduated in difficulty, and short enough to permit fairly complete study. In view of the growing importance of other types of civil engineering work, it would seem desirable to broaden the scope beyond the customary structural projects. The exercises should be short, and the student should be allowed time to do his own thinking. In starting a new course of this type for seniors, the staff of the whole civil engineering department should cooperate in finding and selecting suitable problems.

The writer has used this method of teaching design for courses in both steel and hydraulic structures. Special courses under structural and sanitary engineering instructors have also been given to small groups of graduate students in the department. In steel, the problems have been mainly structural, progressing from the simple garage discussed above to industrial buildings and bridges. In the other courses, problems requiring a wider range of basic knowledge have been used. One good example is the design of a pump house; this involves hydraulics, soil mechanics, and structures. A temporary weir to be built in a storm sewer provided good hydraulic and structural practice and developed a good appreciation of the necessity of considering the method of construction.

On some of the problems, a complete range of the more obvious designs was prepared every year, yet hardly a year passed without some novel design appearing. The best design so far obtained on one problem was produced by a student who, despite rather mediocre computational ability, became a designer of recognized standing within a few years after leaving the classroom.

Students in design courses should always be given a little instruction to prepare them for the task of "checking." There are two possible guiding philosophies for the "checker." When the contrast is brought to their attention, they can select the one that is more likely to lead to success, and are less likely to follow the other without thinking. One is "Never leave any feature of the design the way it is if you can think of any possible reason for changing it," and the other "Never make a change in the existing design unless it is absolutely imperative."

The dangers of "checking" designs by verification of the detailed computations should be pointed out and the students trained to check from completed plans, starting with the most important general features and following through to the details. A most satisfactory examination can be given by asking the class to check plans that embody several defects; these, of course, should vary in conspicuousness and importance.

Many skillful teachers have known the methods described herein and have used them, usually in the courses in steel and masonry which almost

always have enough computation periods to give time for practice. Unfortunately, however, many have not. Even where good methods of teaching design have been used, the methods have too often been solely structural. There is no reason why the student's background in other fundamental subjects should not be drawn upon. The philosophy is, of course, the same as that underlying the "case method" or "project method" used in other fields of engineering.

Many employers say that they would rather have young graduates well trained in fundamentals than in particular applications. What they mean, of course, is men able to apply their knowledge of fundamentals to new problems. This demands creative or problem-solving *practice*, not merely a more nearly perfect or more extensive memory of the fundamentals. We should act now to insure that at least a small part of the student's training will be this kind of practice, and not all of it the sort of instruction that is in reality a conducted tour through interesting applications devised by others.

CORNELL SCHEDULES ELECTRON MICROSCOPE COURSE

"Techniques and Applications of the Electron Microscope," a summer laboratory course intended to offer an intensive survey of basic theory and data interpretation, will be given from June 11 to June 23 by Cornell University's Department of Engineering Physics. Under the direction of Professor Benjamin M. Siegel, the course will have as guest lecturers Cecil E. Hall of the Massachusetts Institute of Technology and Robley C. Williams of the University of California at Berkeley.

Registration is limited, so that ample facilities will be available for each member of the group to pursue laboratory work in his special field at an introductory or advanced level, depending on previous experience. Inquiries should be addressed to Professor Siegel, Rockefeller Hall, Cornell University, Ithaca, New York.

ANOTHER LOOK AT GENERAL STUDIES

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President Jess H. Davis's reflections on "General Studies for Engineers" ought not to go unchallenged, though one cannot help feeling that to "reply" to President Davis's article in the October issue of the JOURNAL (p. 109) is to take unfair advantage of the willing speaker who plays (as I think he does) the devil's advocate for the purpose of encouraging discussion. President Davis's words have an eager and a nipping air about them which is bracing, and his forthright manner does not want for sincerity. Therefore, so as not to appear unsportsmanlike, I should say that I respond to President Davis in the same spirit of impromptu "give and take" that he shows in his paper.

At the outset, I feel at a slight disadvantage. President Davis's animadversions tend to put one in the position of defending "Culture for Engineers," which I cannot do. Like him, too, I am at a loss to know *for sure* what culture means in this context. Or, if it means what I suspect it means, then one must confess that he would scarcely wish to waste his time defending so provincial a notion. Moreover, I know of no *teacher* of the humanities today who would be so absurdly old hat as to subscribe to, let alone preach, the idea that humanistic learning is intended (for engineers or for anyone else) as something *ornamental*, to be displayed only on ceremonial occasions.

Indeed, that is the first and most important point I have to make (and it is, I believe, central to the issue). Humanistic learning is a discipline in its own right, ancient and honorable, with a vast body of knowledge from which to draw. It has its own ancient, honorable, and effective methods of inquiry, with a vigorous pride in the inexhaustible riches it is heir to. It has its own profound and determined desire to preserve the best, with its own highly disciplined scholarship, with its own logic (just as severe in its way as the logic of science), its own ideals of perfection, its own dedicated minds.

One might as well let the cat out of the bag at once. Humanistic learning is not adjunct to any other body of knowledge or methods of inquiry. If one wished so to construe their place in engineering education, one might say that the humanities are interlopers; but no one could accuse the humanities of being Johnny-come-latelies in the noble society of learning.

President Davis shares with many other administrators the notion that the humanistic-social stem in engineering education is auxiliary to the science of engineering. No one now would think of denying chemistry or physics or mathematics an autonomous place in the liberal arts college; why

should one venture to suppose that the humanities should be service appendages to chemistry or physics or engineering mechanics in an engineering college?

Though President Davis does not insist that the "results" of humanistic study must be capable of quantitative measurement, still he is uneasy because he cannot (both as administrator and as engineer) determine how close "we" come to meeting the objectives of the humanistic-social stem in engineering education. The general objectives of the humanistic-social stem, as stated in the 1945 Report of the Committee on Engineering Education After the War, are, President Davis finds, presented in words both indefinable and perplexing. Of course they are—from the strictly engineering point of view. Considerable credit should be given the members of the Committee for the daring they showed in mapping out a direction without benefit of slide rule.

Still greater credit should go to those members of the recent Committee on Evaluation of Engineering Education for the broad and forceful stand they have taken in re-affirming the earlier ideals and directives. One must remember that these committees were not writing systematic philosophies of education, but were taking upon themselves the roles of explorers trying to establish a line of march.

Humanistic-social aims cannot be expressed algebraically or trigonometrically. They were never intended to be subject to the kind of universal agreement which numbers so easily command, and they never will be. But they are responsive to another kind of measurement—the human in its fullest sense, that is, in terms of wholly human values. And the achievement of human values cannot be accomplished all of a sudden, say in four college years. It may well take three score and ten years before the candidate is ready to be examined in his humane learning.

What enlightened board of trustees ever had the temerity to say that the student must have accumulated a measurable quantity of humanistic understanding—intellectual courage, tolerance, aesthetic awareness, emotional maturity, creative sensibility, compassion—by the end of his senior year? If one thirsts for more concrete terms with which to talk about the objectives of the humanities, it will be no refreshment to turn to the physical sciences for a loan of their language. One has rather to draw more deeply from the well of the humanities themselves. There is meaning in the term "human values," though as with a differential equation, the meaning may not readily be grasped until one has given the prerequisite studies considerable attention. A mark of engineering science is that it can be mastered, after a fashion, in four or five years of undergraduate study; it is equally a mark of humanistic learning that only a rare soul ever masters it, even after a fashion.

As all teachers of the humanities know, humane learning often has to deal with subtleties that defy systematic analysis and formulistic presentation. In the arts particularly, discursive reason may be the least rewarding approach to their understanding and enjoyment. Indeed, the enduring strength of a piece of literature may lie in its "non-rational" manipulation of symbols, its ambiguities and ambivalences, which have to

be surprised by insights and intuitions if they are to be captured at all. I am reminded here of a verse by Marianne Moore entitled "Poetry," which opens with these lines:

> I, too, dislike it: there are things that are important beyond all this fiddle.
> Reading it, however, with a perfect contempt for it, one discovers in
> it after all, a place for the genuine.

Are not all the humanistic studies striving largely to find the genuine and bring it to light, wherever it may lie hidden, in science or the arts? If at times the humanistic approach to reality is quite different from the scientific approach, it is not for that reason dispensable. The competent humanities teacher finds himself in a position where he can appreciate and give credit to both points of view. Is it too much to ask that the engineer pay his respects to the humanistic approach, which, though often different from his, is in its field equally valid and successful?

Subject-Matter

When President Davis turns his attention to the subject-matter of humane learning, to the content of courses in literature and the fine arts, for example, he presses hard on the most sensitive area the teacher of the humanities has had to learn to live with—lack of motivation on the part of engineering students toward the humanistic studies. Of course President Davis is right when he says we must first capture the interest of the engineering student. His remarks in this connection are unarguable, and the humanities teacher breathes agreement with him.

That engineering students have a very high degree of motivation toward their engineering subjects and a low (though not so low as some would put it) degree of motivation in the humanities is a fact not better known to anyone (not even to a college president) than to the "plain" classroom teacher. But the teacher of humanities (or of the social sciences) in an engineering school is a confirmed optimist, and he tries unwearyingly every device known to Heaven and man to motivate student interest in the enduring works of the human mind and imagination. Engineering students have very lively minds, capable of reaching out in many directions enthusiastically—if encouraged.

To be sure, there is nothing wrong with beginning with the modern writers in a literature or in any other course. There is everything right with introducing students to literature by way of Bernard Shaw or Sinclair Lewis or Scott Fitzgerald or Dreiser or Hemingway. And the truth of the matter is that most freshman English courses in engineering schools make it a point to introduce the student to literature by way of the modern. But this is only the beginning. Where do we go from here? Somewhere, sometime, we are going to have to face Shakespeare and Dante. Give the good teacher time, and he will find a way. Only be sure that you do give him time.

As head of a Department of Humanities, I have found not so much that the great writers and thinkers are unteachable, but rather that they require a *good* teacher. And most colleges (engineering and other) are not willing to pay for good teachers, either in time or in money. What makes a good humanities teacher? Just this —as thorough a knowledge of his subject-matter as the engineer has of his,

and in addition an abundance of time —time to work with and for his students, time to think about what he is going to do, time to do it in, time to develop himself, and time for study and reflection.

To give a teacher time for his work means freeing him from heavy teaching assignments, from responsibility for large numbers of students, from busy-work, administration, from the casual and non-essential. It often seems that the teacher is expected to do just about everything *but* teach. He draws up syllabi which tell what he is going to do; he writes reports and fills out questionnaires which tell what he has done. I sometimes wonder when he really does what he says he does. Give the devoted teacher time, and he will find a way to interest engineering students in the mighty works of the past. And give the engineering students more time in which to prepare for their humanities subjects, and the curve of motivation will rise with astonishing speed.

Nor is the charge of superficiality which President Davis levels at humane learning in engineering schools quite merited. Depth of knowledge is a matter of degree, as President Davis must know. Since the aim of the humanities is the humanizing of the student (any student—engineering, medical, business administration, or liberal arts), it is perhaps not a question of subject matter to be consumed or even a problem in deepness of inquiry. In other words, it is not a matter of imparting a given quantity of concrete, objective, testable pieces of information, but rather a question of enriching the individual student's own personality, of broadening his outlook, of civilizing his attitudes. And given the small amount of time allotted the humanities and the social sciences in engineering schools, the wonder is that teachers of humanities do as well as they do.

President Davis is an old-school engineer. I am an old-school liberal arts man. I salute President Davis's thought that objective measurement is a worthy aim in the branches of human thought where it is applicable. I would like to feel that he is as ready to pay his respects to mathematically unmeasurable literary values, abstract philosophic thought, and to the complex of human values which is inevitably a part of the human condition. If the engineer will make allowances for the humanistic approach to experience, as the humanist makes allowances for the scientific approach to material reality, together they will make a distinguished pair. The result will be the new-school engineer-humanist who has the advantages of both points of view.

(The quotation from Marianne Moore, *Collected Poems*, 1951, is reprinted by permission of The Macmillan Company, N. Y.)

AIM FOR AMES IN JUNE!

A MATHEMATICS TEACHER LOOKS AT ENGINEERING COURSES

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There seems to be a growing tendency in our engineering colleges to center the teaching of advanced mathematics at least within the engineering college itself rather than to have the mathematics department do it. Obviously the engineers are dissatisfied in some sense or other with the work the mathematicians are doing. One reason frequently given is that there are already too many courses the student must take, and he does not have time for a separate mathematics course. Therefore it is not possible to require mathematics beyond the calculus, and additional mathematics can be taught in the engineering courses as the need arises.

This makes for such courses as electric circuit theory (as given in some schools), which turns out to be the equivalent of an advanced mathematics course, including solutions of polynomial and transcendental equations, some elementary differential equations, practical Fourier series, plus Fourier and Laplace transforms, with a smattering of Gamma and Bessel functions. Similarly, much time in a course on mechanical vibrations is spent acquiring information about the sine curve and its uses.

On the other hand, much of the mathematics a student has learned is not put to use. Consider the beam deflection problems in elementary strength of materials. Here it really does not matter whether the student can integrate such a function as $x^n\,dx$ or not. An entirely new method—that of moment-area diagram—is taught him. (We must admit, this method *is* quicker and much simpler, once you get the hang of it!) Or consider the problem from the advanced strength of materials text, in which the object was to show that a certain phenomenon gave rise to the equation of a straight line. Polar coordinates were used and the polar equation of the line was achieved without too much effort. But apparently a student sufficiently advanced to take such a course is not supposed to know about polar equations of lines, for the text gives in detail the mathematics necessary for change into the rectangular form before it dares state that the result is a straight line.

Again, there is a waste of time and duplication of effort between the engineering faculty and the mathematics faculty in teaching such things as moments or areas and volumes. It is not at all unusual for a student in integral calculus to come up after class when work on moments or volumes has been started and remark that he is doing the same thing in statics. Of course such duplication does not hurt the student, but in view of the fact that he has so much to cover, is it quite wise? (Duplication is not always the case, incidentally. The engineers'

fears are sometimes justified, as evidenced by the student who said he had just completed a course in integral calculus in which the teacher had not solved one practical problem!)

Just what, then, is the place of mathematics in the engineering curriculum? What should be taught? Who should teach it? How can these matters best be decided in a given situation? To settle the easiest question first, mathematics should definitely be taught by the mathematician, the one who is trained to teach it. If there is one on the engineering faculty trained in mathematics, there is no good reason to forbid his teaching the mathematics required if such seems to be desirable.

The term "being trained in mathematics" implies a person who could equally as well have obtained a position on a university mathematics faculty as his present engineering appointment. If this is not the case, it must be assumed that the members of the mathematics faculty are better trained and more qualified to teach the mathematics courses than are the engineers.

On the other hand, it is perfectly true that all mathematicians are not equally adapted to teaching engineering students. If possible, the student should be under someone who is familiar with the engineering curriculum. If the mathematics teacher is not acquainted with the curriculum, he should become acquainted with it. The engineering college should cooperate, but it can expect the mathematics teacher to take the initiative.

Psychologically it would be good if engineering classes, especially in elementary mathematics, could be set up for engineering students only and could meet in regular engineering classrooms. This would keep the instructor reminded of the fact that he was teaching mathematics primarily as a tool, and would give the freshman more of the feeling that the mathematics was actually a part of his engineering training rather than just another extraneous required subject.

This brings up the next question of what mathematics should be taught. If two people can be found to agree on this matter, I do not know where they are. [*Editorial Note:* Some advanced-subject progress is apparently being made on Miss Rohde's point, as the Report of the Pasadena Conference on Mathematics, page 585, may show.] Yet I feel definitely that certain topics should and could be omitted for the engineering student, with others emphasized more than they presently are.

There is no reason why the algebra, trigonometry, analytic geometry, and differential calculus needed cannot be covered in the first year of college if a little cooperation is established between the mathematics and engineering faculties. The engineers will have to take time to inform the mathematicians just what subjects or emphases are and are not needed for engineering practice. The mathematicians will then have to teach with these goals in mind, or convince the engineers that other methods would be better. Certainly all theory cannot be omitted, for, though mathematics is to be primarily a tool, a certain amount of "mathematical maturity" is necessary to undertake intelligent study of special topics, primarily those required for advanced degrees.

One of the criticisms of present mathematics courses, both elementary and advanced, is that there are not enough practical problems solved in

class or assigned for homework. Members of the engineering faculty could help here by taking an hour or two and writing out some practical problems that might be used in the mathematics courses. These could be filed by the mathematics group, and added to from year to year, making a good supply of problems available at all times. Such problems, incidentally, should realistically include extraneous information, so that the student would need do more than find a formula involving exactly the quantities given in the problem and then substitute. (One of the most harrowing experiences of my life was to be given a problem in strength of materials in which there was some information for which I could find no immediate use!)

Except for the rare two-year unified courses, the first mathematics most college freshmen encounter is algebra. Here several weeks are sometimes devoted to a review of high school work, even going back to what was done in the ninth grade.

For a student qualified to take the course in the first place (one with two years of high school algebra and sometimes more) nothing could be worse than this method of beginning the semester. He feels it is only a "rehash" of something he has already had; he gets by with little or no study; the pattern is set. He is not going to do any studying for the rest of the semester in that course. Such things as the solution of linear and quadratic equations, factoring, and handling of fractions can just as well be reviewed on the student's own as he finds necessary. This would be the scholarly way of doing things.

If we must start with something simple, a discussion of inequalities might well be in order. The student would feel he was learning something new and would begin a program of *study* rather than of neglect for his mathematics. The two or three weeks saved could be devoted to solutions of polynomial equations by numerical methods and other desired topics.

As for trigonometry, a thorough foundation in the measurement of angles, both by degrees and radians, in the trigonometric functions, and in the fundamental identities and their use would seem sufficient. Certainly these topics are needed, either immediately in engineering, or for the development of the so-called mathematical maturity mentioned earlier. Special attention should be given to the discussion and graphing of sine and cosine curves, with amplitude, phase, period, and frequency emphasized. The addition of ordinates in graphing linear combinations of such curves is also most useful. The development of the sine and cosine formulas and others for solving triangles is hardly necessary; possibly two or three days could be spent on their use.

This would be a good place for a discussion of significant figures and rounded numbers, a subject which is important to the engineer. Since there are so many different opinions about this subject, it would be well for the mathematics and engineering faculty to have a common method. Occasional practice in the engineering classes of carrying an irrational number in its exact form, such as π, $\sqrt{3}$, or $\log_{10} e$, to the end of a problem would not be amiss, either. After all, 2.828 may look like $2\sqrt{2}$, but it might represent almost anything else as well. Suppose you decide at the last minute you want five significant figures and are not sure about their validity?

Most of the time spent in analytic geometry on the conic sections (in other words, most of the time spent in analytic geometry, in many cases) would seem to be wasted on the engineering student. To paraphrase a verse of Scripture, "For what is a man advantaged, if he gain the equation of the directrix in the new coordinate system after the axes have been translated and rotated, and recognize not the equation of a straight line or a circle in polar coordinates?" To know that $5x^2 - 13xy + y^2 + 2x - 10 = 0$ is an hyperbola is enough without being able necessarily to put it in standard form.

Probably the greatest objection to the teaching of calculus is the failure to emphasize the use of integral tables. As we all know, much time could be saved for more important things if the student were allowed to use tables in integrating functions such as $(3x + 1)dx/(2x^2 + 5x + 8)$. Again, since the engineering courses cover thoroughly the subjects of moments, areas, volumes, and the like, possibly some of this work should be omitted in the calculus and the time devoted to other topics, say an introduction to differential equations.

In a course streamlined for engineers along such lines as have been suggested, I feel certain that the student could be given in three semesters as much *necessary* mathematics as he now gets in four. The fourth semester could then be devoted to a good course in differential equations which would include special emphasis on graphical and numerical methods, series solutions including Bessel functions, and boundary value theory with applications to specific problems in engineering. I have no proof for this statement, for I have never had the opportunity to try such a thing, although I would certainly like to do so.

With the exception of the differential equations, there is probably no single text which would be suitable for any one or two semesters of such a program. Of the so-called unified texts today, all are written for wider audiences than just the engineering student. Sometimes I think a student learns more without a text, anyway, when he has to pay attention and take notes. Certainly there would be plenty of reference material. Given a teacher interested in his work, the program should be a success for two reasons: first, the student would know he was getting something he could use later on; and second, he would have to work harder from the beginning and so would get into the habit of studying regularly.

Assuming subjects taught as outlined in the first two years, there should be little necessity for the engineering faculty to do more than a cursory review of any mathematical subject in their courses. The student who needs more mathematics will then be able to find time for advanced courses covering such topics as vector analysis, partial differential equations, complex variables, matrix theory, Boolean algebra, and so on. Vector analysis and partial differential equations with some applications can be covered in a three-semester-hour course, as can the complex variable theory needed for the more elementary applications. These are probably the subjects most often required. By the time a student has got through this much mathematics, he is usually mature enough to learn for himself by reading what he needs of other topics, given appropriate references.

Finally, to aid in the success of any

such program, there must be direct exchange of ideas between engineering and mathematics instructors. When an engineering instructor finds that a particular mathematics course, especially one which has been designed for the engineering student, contains more theory than he thinks it should or omits something he thinks should be included, let him tell the mathematics faculty about it *in person*. He must remember that the mathematician teaching the course will probably be only too glad to get suggestions, but that the students do not always pass on everything that is told to them. A joint effort by mathematics and engineering staffs, however, will go a long way toward advancing the efficiency and usefulness of mathematics instruction as a part of engineering curricula.

"JETS" HIGH SCHOOL PROGRAM

Junior Engineering Training for Schools (JETS), a science-club plan originated in 1950 by Lorin G. Miller, former Dean of Engineering at Michigan State University, now includes 75 clubs in eighteen states, with an active membership of more than 2,000 high school boys and girls. The JETS program is intended to do for engineering what 4–H and FFA have long been doing for agriculture.

The JETS clubs get first-hand information from a variety of sources. Projects are recommended, conferences and talks are scheduled by college staff members or industrial engineers, films and publications are obtained for study and review. To help clubs get started, JETS headquarters has supplied lists of suitable projects, and an index of more than 100 motion pictures available without charge from industry and other organizations. Added incentives for members of JETS are provided by judging recognition of club projects and by scholarship awards to the outstanding member in each club.

Success of the JETS program has already brought requests for information from more than 60 engineering colleges, societies, and industries. The JETS idea has been developed as a national secondary-school pattern which can be utilized freely by engineering colleges everywhere. Director Harold P. Skamser, School of Engineering, Michigan State University, East Lansing, offers assistance to ASEE institutions and industries in adapting the basic JETS plan to the special needs of their own areas.

SENTENCE AND WORD LENGTH IN SCIENTIFIC WRITING

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Scientific writers are frequently urged, rather arbitrarily, to shorten their sentences and words. Too often it seems that those who would change the scientific writer's style in these respects do not fully appreciate the special problems of the field. In scientific and technical writing, sentences frequently must be long in order to express essential qualifications and reservations, and short equivalents for polysyllabic terms often do not exist.

Perhaps the attention that the various systems for measuring readability have received in recent years is responsible for a general feeling that all writers should shorten their sentences and words. These readability measuring systems are based on sentence and word length; quite simply, the longer a writer's sentences and words, the lower will be his readability rating. One would question the validity of such crude measuring systems. Although it is true that sentences containing non-associated ideas are low in readability, all long sentences do not err in this respect; and although polysyllabic words may, in general, be less familiar than their shorter equivalents, this is not always the case. Moreover, as has been observed, in scientific and technical writing polysyllabic terms are unavoidable.

Readability means nothing more than reading ease, and scientific writing should certainly be easy to read whenever possible. However, in this type of writing, reading ease does not necessarily result from simplicity of expression. For exposition, completeness and precision are essential; if these qualities cannot be obtained by the use of short sentences and short words, long sentences and long words must be used. An attempt to convey a sophisticated concept in short sentences and short words could easily be less readable than a more complex, and hence more appropriate, expression. It may well be that the reader of scientific and technical material, accustomed to devoting a measure of attention and concentration to his reading, feels that *necessarily* long sentences and words are quite readable.

Scientific vs. Popular

In fact, the readability measuring formulas proposed by Flesch and his followers for popular writing fail to distinguish between sentences and words that are necessarily long and those that could be shorter without loss. This failure to distinguish levels of communication responsibility suggests that these systems may be misleading if applied to practical writing.

So much for theory. It now remains for this theory to be tested. The purpose of this paper is to report the results of an effort to determine the correlation, if any, between the length of sentences and words in scientific writing and the readability of that writing, as judged by those who normally read it.

Test Evaluation

Representative samples were drawn from 17 reports in the field of science (one sample from each report) and were rated by means of the readability rating system developed by Rudolf Flesch.[1] In this system the average number of words per sentence and the average number of syllables per 100 words are computed; then, by means of a formula[2] developed by Flesch, these averages are expressed in terms of a Reading Ease Score. This score ranges from 0 to 100; the shorter a writer's sentences and words, the higher is his score. By this token, the higher his score, the better writer he is. (A comic book, for example, in which half the words are of one syllable and the other half are two syllables, and in which all the sentences are five words long, would have a Reading Ease Score slightly under 75. A perfect score, of course, can be obtained only by mono-syllabic one-word sentences; random nonsense would qualify beautifully.)

The Flesch Reading Ease Scores for the 17 samples of scientific writing ranged from 23.4 to 45.3. The mean for the samples was 29.4. Six of these 17 samples were used in the test: the two with the highest Reading Ease Scores (45.3 and 36.2), the two with the scores closest to the mean (28.8 and 26.4), and the two with the lowest scores (both 23.4). These six samples were then evaluated by eight readers who had no prior knowledge of the Reading Ease Scores.

The readers were research workers who had undergraduate degrees and some graduate school training in both the physical and the social sciences; the reports concerned investigations and experiments in the physical and social sciences. Each reader completed a questionnaire for each sample, in which he stated his opinion both as to the sample's capacity for being understood at one reading and its capacity for being summarized faithfully. The readers also indicated the approximate number of words requiring reference to a dictionary. Finally, the readers assigned a rank order to each sample, indicating how they felt that particular sample compared with the other five in general readability.

The most remarkable result of the test was that the average (mean) rank order of readability assigned by the readers was almost exactly in reverse correlation with the rank order according to the Flesch Reading Ease Scores (see Table 1). It will be observed that the reports rated first and second for readability according to the Flesch system were fourth and third for the six readers. The two selections rated last according to the Flesch system were placed first and second by the readers.

Analysis of the questionnaires showed some correlation between the rank order assigned by the readers

[1] *How to Test Readability*, Harper and Brothers, New York, 1951.

[2] $(RES) = 206.835 - [1.015\,(ASL) + .846\,(NS)]$, where RES is the Reading Ease Score, ASL is average sentence length, and NS is the number of syllables per 100 words.

and their opinion as to ease of summarizing, and somewhat less correlation between that rank order and the opinion concerning capacity for being understood at one reading (see Table 1). No correlation was observed either between the rank order assigned and the number of sentences that had required rereading, or between the order and number of words that had to be looked up in a dictionary (see Table 1).

The results of this admittedly limited experiment suggest that, in scientific writing, there is no correlation between readability as measured by sentence and word length and readability as judged by trained readers. Thus, the current readability measuring systems are based solely on mechanical factors of sentence and word length alone, without considering content or quality of thought. They are apparently not valid for and should not be applied to scientific writing. One can only hope for a more critical examination of the theory that long sentences and long words reduce readability and that, eventually, this theory will no longer inspire arbitrary attempts to alter the style of competent writers generally.

Editor's Note: The Flesch Reading Ease Score for the first four paragraphs of this article is 29.3, which is slightly higher than the mean of the scientific articles compared by the author. It is interesting to note that the first 100 words rated 23.3, or slightly more difficult than the hardest of the technical articles used in the comparison.

TABLE 1

COMPARISON OF FLESCH READING EASE SCORES WITH EVALUATIONS MADE BY ACTUAL SCIENTIST-READERS

Sample Letter	Flesch FRES	Rank in RES	Reader's Rank	Comment on Summary	Comment on Understanding Single Reading	Sentences Requiring Re-reading	Words Requiring Use of Dictionary
F	23.4	5	1	excellent	excellent	moderate	low
E	23.4	5	2	excellent	excellent	low	low
B	28.8	3	3	excellent	excellent	moderate to high	low
C	36.4	2	3	fair	excellent	moderate to high	high
A	45.8	1	4	fair to poor	fair	high	low
D	26.4	4	5	poor	poor	moderate to high	low

"CASE STUDIES" INCREASE INTEREST IN MATERIALS LABORATORY

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That dull course in "materials testing laboratory" can be changed into an interesting and creative contribution to the student's store of knowledge. Too often this potentially great laboratory course becomes a formality of following specific instructions, taking data, and writing reports. The organization of the experiment, the data needed, the original background and preparation, all are missing. When the same experiments are repeated each semester, the instructor finds a direct similarity between the reports received. This indicates that the students are not thinking for themselves, but are leaning on previous reports to do their thinking for them. It is also difficult for the busy instructor to sit down and write a complete new set of experiments each semester without any repetition. As a consequence it seems proper that some way should be found of creating additional experiments without undue expenditure of time. The obvious answer, of course, is to interest the student in writing the procedure for the experiments himself, either on his own or during class periods.

The testing laboratory schedule at Wichita University was recently revised as an attempt to interest students in testing procedure. The class was first divided into two groups, and problems rather than experiments were assigned to each group. Instead of reports, the students in group A were required to write a procedure to be followed by group B at some later date. The problems were composed in a fashion to interest the student in determining why the test was necessary and what results were needed to solve the problem properly.

An example of this type of problem follows:

"A law suit developed over the collapse of a roofing truss. The insurance company refused to pay damages, contending the truss was poorly designed and inadequate to support its own weight. Arguments in the courtroom resolved into how much column load could be applied to the ends of each section of the 4×16 timbers. The judge recessed court and asked you to run tests upon some sample timber taken from the fallen truss. Since there were various lengths of span pieces, you must explain the variation in allowable load with length and section shape. The report must use clear and simple English that the jury of laymen can understand. The collapse of the truss occurred during a rain storm, so the timber could have been saturated at the time of failure. The sample submitted for test is $2'' \times 8'' \times 10'$ and can be cut into any size specimens required. Your problem is to write a procedure for the experiment and explain what results are necessary to satisfy the jury." (Actual court case in

U. S. District Court—DeLuxe Lanes *vs.* Worchester American Insurance Co.)

Under the guidance of the instructor, the procedure-writing group laid out a step-by-step routine for the second group to follow in performing the experiment. The experiment was then carried out by the procedure-writing group according to this outline, and the necessary data were taken. An evaluation was then made by the group on whether the data would produce the desired results, and any suggestions for improvement in the method were discussed. Finally, the group submitted a formal procedure for the second group to follow.

The second group was allowed to make written comments as they followed the procedure submitted by the first group. These comments greatly assisted in grading the report and also in the student's self-evaluation when his turn came to write a procedure. The full report was then written by the second group and re-submitted to the first group for approval.

The viewpoint of the practical application was clearly contained in each problem and was presented to point out some function of testing laboratory work in industry. The knowledge of the audience to which the report was directed gave the students a satisfactory basis for evaluating the ideas presented and for excluding any rambling or unnecessary material. Each problem was planned to familiarize the student with a different phase of testing so the scope of the course would not be changed and the student would get his basic background knowledge through individual problems. An example of this diversification is shown by the experiment dealing with the stress-strain recorder:

"You are employed by a manufacturing plant as head of the testing laboratory. A salesman has proposed that the company purchase an automatic stress-strain recorder for use on your testing machine. Your responsibility is to use the device and your own machine to verify the physical characteristics of the material employed in the saleman's demonstration. You are not trying to sell the equipment, but the decision to purchase will be based largely on your report. The management, of course, has full technical knowledge of your operation; a complete but terse presentation of your findings is desirable. You are to write a procedure for your testing group to follow as they prepare a report on the advantages and accuracy of the equipment."

The above plan has been in operation for two years, and has been a source of satisfaction to all concerned. One of the few difficulties encountered was that occasionally the student writing the procedure expressed himself too vaguely for the experimenters to follow readily. This was overcome to a considerable extent by requiring that an outline of the procedure be included in the report. The outline both improved the report and gave experimenters a clearer picture of the problem.

In preparing these procedures, the students write fewer total reports, but the experience in giving clear instructions more than offsets any lack of practice in composition. The students now ask questions that show interest and comprehension of test methods. Finally, the approach used here, that of writing procedures and executing them, need not be confined to testing, but can be used with equal success in many other laboratory courses.

VOLUMETRIC EFFICIENCY

A Critical Evaluation of an Ambiguous Term

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From the mechanical engineer's viewpoint, one of the most abused concepts in the realm of applied thermodynamics is that of volumetric efficiency. A concept which is basic to the analysis and performance of positive displacement machinery, volumetric efficiency seems to mean a number of different things to different people. Although mechanical engineers feel intuitively that volumetric efficiency is the ratio of the amount of gas drawn into a piston engine or compressor to the displacement of that machine, various sources define the term from conflicting points of view. This lack of uniformity among authors has been a source of confusion to students in successive courses dealing with thermodynamics, heat power, and internal combustion engines.

Compressors

For the analysis of air compressors, most writers define volumetric efficiency as the ratio of free air delivered (in cubic feet) to the piston displacement (cubic feet); free air, of course, is defined as the air drawn through the suction or inlet valves. Some authors, however, define volumetric efficiency as a weight or mass ratio: i.e., the mass of fluid actually inducted per stroke divided by the theoretical mass of fluid required to fill the piston displacement volume under atmospheric conditions. When a perfect gas relationship is assumed, the two definitions are equivalent; nevertheless, the apparent contradiction is an irritation to the student. Also, the conversion from mass to volume implies additional assumptions which are not always obvious.

A more serious disparity lies in the development of either definition into a usable mathematical relationship. The development can be found in any engineering thermodynamics text and will not be included here, but the usual thermodynamic treatment involves the use of several quantities: C = per cent clearance expressed as a decimal fraction; P_1 = the pressure of the fluid in the cylinder at the start of compression; P_2 = the pressure of the fluid at the end of compression; n = a polytropic exponent; and P_a = the pressure of the fluid under "free" conditions.

This last quantity is the major point of contention. When all the quantities are considered, the expression for volumetric efficiency is

$$\eta_v = \frac{P_1}{P_a}\left[1 + C - C\left(\frac{P_2}{P_1}\right)^{1/n}\right].$$

However, some authors completely ignore the effect of throttling across the intake valve and tacitly assume that $P_a = P_1$. Although most thermodynamic studies are based on simplifying assumptions, this one contributes little, if anything, to the analysis. Throttling, or some other significant irreversible expansion, most assuredly does occur across the suction valve, and this fact should be pointed out to the student.

The problem is further confused by failure to distinguish between wet and dry gas. Generally, this distinction is not made in an introductory thermodynamics course, but certainly it should be in subsequent studies. Unfortunately, many authors neglect this phase of the material even when the rest of their analysis is rigorous. All definitions of volumetric efficiency are evasive in this respect, but inasmuch as, say, compressed water vapor is not the desired end product from an air compressor, it may be assumed that bone dry air should be considered. A few psychrometric calculations can yield the desired result. Although the analysis is somewhat more complex than the case of throttling across the intake valve, it should at least be mentioned.

In most instances, neglecting both throttling at the intake and moisture in the gas will not change significantly the magnitude of the volumetric efficiency for any given compressor. The value of more accurate and realistic considerations lies in the training given to the student. He should be made aware of the existence of these factors so that, if the necessity ever arises, he can cope with them successfully. At least he can intelligently neglect their effects rather than be completely ignorant of them.

The case of volumetric efficiency for a piston type internal combustion engine also deserves more consistent and complete treatment by authorities. Here there is reasonable agreement for the air standard engine; the disparities occur for the real engine. Also, for neither engine is any attempt made to develop an expression in terms of clearance and related factors.

Internal Combustion Engines

To illustrate, the following definitions are taken from two popular internal combustion engine texts and an equally popular heat-power text:

"Volumetric efficiency is defined as the ratio of the charge inducted, at the atmospheric conditions surrounding the engine, to the piston displacement. Only the volume of air inducted is considered when using liquid fuel."

"The volumetric efficiency of an engine is defined as the ratio of the actual weight of air inducted by the engine on the intake stroke to the theoretical weight of air that should have been inducted by filling the piston displacement volume with air at atmospheric temperature and pressure."

"Volumetric efficiency may be defined as the quotient of the volume of the combustible charge drawn in, reduced to standard temperature and pressure, divided by the piston displacement. It is really the ratio of the mass of the charge actually drawn in to an ideal mass. The standard conditions may be, 1) 60° F and 14.7 psia, 2) the pressure and temperature of the atmosphere surrounding the engine, or 3) the pressure and temperature at the entrance to the induction pipe."

By contrast the following definition appears in the test code of a large automotive engine manufacturer:

"Volumetric efficiency is the ratio of the volume flow of moist air at the carburetor per unit time to the effective swept volume of the engine in the same unit of time."

As pointed out above, the first two statements are equivalent. The third

definition is different in that the "combustible charge" must necessarily include both air and fuel; the choice of "standard conditions" also leads to an ambiguity. The last statement is still further away from the others, in that "moist air" (presumably humid) is specified; furthermore, the condition of the air at the carburetor could be different from the air in some other area adjacent to the engine. Unfortunately, the Society of Automotive Engineers does not deal with volumetric efficiency, so that none of the above can be corroborated by any accepted authority.

Once again, it should be pointed out that the differences in results are not great. Yet it is regrettable that this lack of agreement exists, for it can lead the student to a mistaken concept of volumetric efficiency.

A striking example can be found in a problem (with answer), which appears in a recent edition of another heat-power text. The problem appears at the end of the chapter on internal combustion engines, in which the various performance characteristics are discussed. One of the characteristics is volumetric efficiency, described as the ratio of the actual weight of air inducted to the weight of free air equivalent to the piston displacement.

The problem asks for the bore and stroke of a multicylinder four-stroke cycle engine, and the following information is given: brake horsepower output, average piston speed, volumetric efficiency, mechanical efficiency, heating value of gasoline, theoretical air-fuel ratio (on weight basis), per cent excess air, brake thermal efficiency, stroke-bore ratio, ratio of densities of gasoline vapor to air, and the pressure and temperature of the air and gasoline vapor at the end of the the suction stroke.

This is truly a splendid problem. It requires a good deal of careful, analytical thought. The student cannot plunge wildly into a haphazard solution, nor can he refer to any examples included in the text to parrot a solution. He must sift the data, rearrange so that they will yield additional information, and then carry through to a solution. The problem is as thorough as it is basic, and the author deserves credit for having formulated it.

When a text problem is as rigorous as the one in question, it is frequently advisable to include the answer so that the student will recognize whether or not both his method and calculations are correct. Unfortunately, in this particular illustration the answer given is *incorrect* by a factor equal to the volumetric efficiency. From the statement of the problem, the volumetric efficiency does not even enter into the solution. The actual weights of air and fuel per unit time can be easily found, as can the specific volumes of these fluids in cylinder. From this information the total volume swept per unit time follows directly. This can be expressed in terms of bore, stroke, and engine speed, and the desired answer can then be found with little difficulty.

Whoever solved this problem apparently did not have a clear understanding of volumetric efficiency. If he had, he would have recognized that volumetric efficiency was not a consideration if for no other reason than that the properties of "free air" were unknown. From the author's

definition of volumetric efficiency, atmospheric pressure and temperature are necessary antecedents to finding the volume of free air.

In many instances, authors will compose the problems and then assign graduate students or advanced undergraduates the labor of finding the answers. This procedure generally proves satisfactory to all concerned, for the student learns a good deal from his experience and the author is spared the tedium of a very routine task. However, it is imperative that the student be well founded in the subject and understand all of the concepts—which were lacking here.

Summary

Although volumetric efficiency can logically be only a single concept, it seems to have been presented under several different interpretations. So long as these divergencies or contradictions are continued, the student will encounter difficulties which may completely obscure more important considerations. It can only be hoped that something constructive will be done to alleviate the situation. Pending action by some standardization committee or code organization, however, instructors in the appropriate subjects should at least note the problem, and should clarify it as best they can.

MOTION AND TIME STUDY INTENSIVE COURSE

Washington University of St. Louis, Department of Industrial Engineering, will present a Motion and Time Study Intensive Course from June 6 through June 15. The course will help those attending to apply motion and time study in their own organizations and to train other persons in conducting such studies. The material presented will emphasize establishing correct procedures before work is started, as well as improvement of existing methods. Further information can be obtained from the Department of Industrial Engineering, Washington University, St. Louis 5, Missouri.

TORGERSEN HONORED

The Heights Alumni Association of New York University recently honored Harold Torgersen, a member of the ASEE since 1935, for twenty-five years of service to NYU. Former chairman of the Evening Education Division of ASEE, Professor Torgersen is Assistant Dean of the College of Engineering, and Professor of Electrical Engineering.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Division of Engineering Drawing
Editor: Albert Jorgensen, University of Pennsylvania

Report on the Midwinter Meeting of the Division

The Annual Midwinter Meeting of the Engineering Drawing Division held at the Illinois Institute of Technology was highly successful. The program included interesting and stimulating papers. Topics discussed including drawing courses for students majoring in science, nomography, the relations of drawing and design, and the problems of simplified drafting.

Chicago lived up to its reputation as a convention city, and a new attendance record was set for the Division. At least twenty-two states and one province of Canada were represented. Total registration exceeded 180, topping the previous high (set also at Chicago), when one hundred fifty-five registered for the Midwinter Meeting at the Navy Pier Branch of the University of Illinois several years ago. Among those present were W. Leighton Collins, Secretary of ASEE, and E. C. McClintock, Jr., Editor of the Journal of Engineering Education. This display of interest on the part of these representatives of the parent society is sincerely appreciated by the officers and members of the Division.

At the meeting of the Executive Committee of the Division, reports of committees were received, and the following items approved, (1) changing the name of the T-Square Page to that used in this issue, (2) the dates, January 30–February 1, 1957, for the next Midwinter Meeting, to be held at Rice Institute in Houston, Texas, and (3) the arrangements for the 1956 Summer School (given below). It was also announced that the 1958 Midwinter Meeting will be held at the General Motors Institute, Flint, Michigan.

You are urged to "AIM FOR AMES" plenty early so that you can attend the entire Summer School for Engineering Drawing, which will be held at Iowa State College. Two hundred members are expected to be present. The School starts with registration Wednesday afternoon, June 20, 1956, and extends through Wednesday afternoon, June 27. Note that these dates overlap those for the Annual Meeting of the Society, which will be held at the same institution on June 25–29.

The program for the School is being developed under the direction of William E. Street, Chairman of the Division, with Professor James S. Rising of Iowa State College in charge of the local arrangements. (The January, 1956, issue of the Journal gives information concerning the host institution.) U. S. highways 30 and 69 and the Chicago and North Western Railroad run through Ames. If traveling by air, members of the Drawing

Division may make arrangements with Jim Rising, at Iowa State College, to have a car meet them at the Des Moines airport, thirty-two miles south of Ames, for transportation to the campus. Ample housing is available in dormitories (Jim says they are good), hotels, and motels. There will be sufficient time for pre-registering and making housing reservations after you receive the final program.

The headquarters for the School will be in Room 403, Marston Hall, and sessions will be held in the auditorium of the Electrical Engineering Building nearby. Registration will open 4 P.M.–6 P.M., Wednesday, June 20, in the Memorial Union Building.

The theme of the School will be "Evaluation of Engineering Drawing for the Future." A preliminary outline of the program follows.

Program for the Summer School on Engineering Drawing Iowa State College, June 20–27, 1956

Thursday, June 21

9 A.M. Address of Welcome and Response

Objectives of Engineering Drawing in Engineering Education
R. R. Worsencroft, *University of Wisconsin*

Correlation of Engineering Drawing Courses
I. L. Hill, *Illinois Institute of Technology*

2 P.M. Motivation Needed in Teaching Engineering Drawing
E. D. Black, *General Motors Institute*

Drawing and Descriptive Geometry Courses Which Comply With the ASEE Evaluation Report
R. A. Kliphardt, *Northwestern University;* H. C. Spencer, *Illinois Institute of Technology;* J. T. Rule, *Massachusetts Institute of Technology;* C. J. Vierck, *Ohio State University*

7 P.M. Orientation as a Function of Engineering Drawing
S. P. Owen, *Rutgers University*

Industrial Planning and Design as They Relate to the Drawing Room
J. A. Carroll, *The Proctor and Gamble Company*

Friday, June 22

9 A.M. Creative Problems for Basic Engineering Drawing
Matthew McNeary, *University of Maine*

A Damper on American Scientific Progress
R. W. Pearson, *Radio Corporation of America*

Graphics and the John Deere Cotton Picker Spindle
C. Gordon Sanders, *Iowa State College*

What You Will See at the John Deere Des Moines Works
Bud C. Lundahl, *John Deere Plant Superintendent*

1 P.M. Inspection trip to the John Deere Des Moines Works

7 P.M. Dinner, Ladies Invited

DRAWING OF TOMORROW
B. L. Wellman, *Worcester Polytechnic Institute*

A SURPRISE!

Saturday, June 23

9 A.M. SIMPLIFIED DRAFTING AS PROPOSED BY THE BUREAU OF SHIPS
R. Wallace Reynolds, *California State Polytechnic College*

DIMENSIONING FOR MASS PRODUCTION
P. G. Belitsos, *General Electric Company*

DIMENSIONING AND CHECKING OF DRAWINGS
H. C. Hesse, *Valparaiso University*

2 P.M. HOW TO MAKE AND USE TEACHING AIDS
R. I. Hang, *Ohio State University*

THE PRINTED CIRCUIT
W. J. Adams, *Bell Telephone Laboratories*

EXAMINATIONS IN DRAWING AND DESCRIPTIVE GEOMETRY
Irwin Wladaver, *New York University*

6:30 P.M. Executive Committee Dinner

Sunday, June 24

3–6 P.M. Reception at the home of James S. Rising

Monday, June 25

9 A.M. CHANGES IN THE ASA DRAFTING STANDARDS
R. P. Hoelscher, *University of Illinois*

AMERICAN DRAFTING STANDARDS IN BASIC DRAWING COURSES
R. S. Paffenbarger, *Ohio State University*

CHANGES IN DRAWING EMPHASIS
R. T. Northrup, *Wayne University*

2 P.M. MOVABLE SCALE NOMOGRAPHS
J. N. Arnold, *Purdue University*

A LESSON IN NOMOGRAPHY
A. Jorgensen, *University of Pennsylvania*

GRAPHICAL CALCULUS
E. M. Griswold, *The Cooper Union*

Tuesday, June 26

2 P.M. Joint Conference with English Division

ESTHETIC FUNCTIONS OF ENGLISH
James H. Pittman, *Newark College of Engineering*, and Frederic H. Higbee, *State University of Iowa*

ESTHETIC FUNCTIONS OF ENGINEERING DRAWING
Wayne L. Shick, *University of Illinois*
A GRAPHIC APPROACH TO ENGINEERING EDUCATION
Frank A. Heacock, *Princeton University*

6 P.M. Dinner, Ladies Invited
Nomography Award ($100 for the best Nomograph of the year)
The Distinguished Service Award of the Drawing Division
MAKING FACES
Herbert V. Hake, *Iowa State Teachers College*

Wednesday, June 27

12 Noon Luncheon and Business Meeting

2 P.M. Joint Conference with the Mathematics Division
A GRAPHICAL APPROACH TO THE STUDY OF CALCULUS
John F. Calvert, *University of Pittsburgh*
AN OPERATIONAL SYMBOLISM FOR GRAPHICAL PROCESSES
S. A. Coons, *Massachusetts Institute of Technology*
GRAPHICAL ANALOGUES OF MATHEMATICAL PROCESSES
J. F. Twigg, *Massachusetts Institute of Technology*

REVISED ASTE DATA SHEET NUMERICAL INDEX

The National Standards Committee of the American Society of Tool Engineers has recently made available a revised Data Sheet Numerical Index adapted from the U. S. Standard Commodity Classification System. The Index is intended to aid the tool engineer in selecting, filing, classifying, and comparing descriptions of all available tool engineering products. The Index comes in two parts: a Numerical Listing which shows the basic seven-figure decimal arrangement, and the Alphabetical Listing, a subject-cross-referencing of the numerical material. Further information can be obtained from the National Standards Committee, American Society of Tool Engineers, 10700 Puritan Avenue, Detroit 38, Michigan.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

JOHN L. ARTLEY, Chairman
Duke University

HAROLD A. FOECKE, Editor
University of Notre Dame

SUMMER EMPLOYMENT– A BUSMAN'S HOLIDAY

Every year about this time many engineering teachers, especially the younger ones, concern themselves about summer employment. That summer employment in industry is one very important and profitable form of the various types of industrial experience for engineering faculty members is affirmed by articles in the JOURNAL in recent years. These same articles indicate that it is also profitable to industry because for various reasons, ranging from the critical shortage of engineering talent to enlightened public relations, opportunities for summer employment are on the increase.

The purpose of these few paragraphs is to propose an additional benefit: that some companies might find it very profitable to employ college faculty members during the summer, not for research or design work, but for teaching. Specifically, they could offer flexible short courses for the young company engineers, who would thereby become more productive for the company and also continue to grow professionally. The following paragraphs will attempt to buttress this proposal with statements designed to show the possible benefits to be derived from such courses by the young engineer, by the company and by the teacher.

The banner cry today is "Fundamentals," stress the science of engineering, concentrate on basic principles, de-emphasize the less stable applications and current practices. This principle has been urged frequently by industrial and educational leaders, and also by all the major studies of engineering education in the past two decades. It must be recognized, however, that while this is the best possible preparation for long range professional needs, the student's immediate productivity after graduation is necessarily somewhat diminished. The new graduate is faced with a somewhat longer transition period before he reaches full professional stature in any specialty than might have been the case if certain senior courses had been tailored to prepare him for such specialized work.

This transition phase, the first five years, is a critical time for the young engineer. While the final responsibility for professional development

naturally rests upon the engineer himself, it has been recognized that the employers of these young men do have responsibilities in fostering professional growth. Apparently new employees in most of the larger industries are at least partly provided for by the organized training programs which these companies already have.

The employees of medium or smaller sized companies are not always so fortunate, and the fact that men in smaller organizations sometimes have closer contact with superiors does not always offset the lack of a thorough and well-planned training program. What a boon it would be to such young engineers if summer programs could be developed to give them some of the more specialized knowledge they need to be productive, and to promote their professional growth and development!

There are many good reasons which in the past have kept smaller companies from establishing organized and formal training programs. But equivalent results could readily be obtained if engineering teachers, especially young engineering teachers, would take the initiative (with company support) in designing summer courses to fit the needs of young engineers.

Such an arrangement would have several advantages. It would give the companies an opportunity of fulfilling an obligation to their employees and still of benefiting from increased productivity. This could be done without asking any of their regular senior staff to drop or curtail their work for the "luxury" of giving some course, not to mention the fact that such staff members, however well qualified technically, simply might not enjoy, or have time for, teaching.

What could be less disrupting of normal routine and more convenient to all than bringing in for a short period a qualified man who has dedicated his life to teaching engineering? Viewed as part of an annual budget, his consulting fees would surely be insignificant in comparison to the benefits derived by getting together a company and a teacher both having imagination and ingenuity.

But, would engineering teachers want to "get away from it all" by going to industry for a summer to *teach*, a busman's holiday if ever there was one? A little reflection indicates, however, that there may very well be some very good reasons why teachers might aspire to do just that. It borders on belaboring the obvious to state that there are many different types of engineering teachers, performing reasonably distinct functions in the whole of engineering education. Such teachers might also profit from varied industrial experiences in research, design, or administration.

And why not teaching? Assignment to work on some particular phase of one particular project may be very rewarding to both teacher and employer. But, while bringing the teacher up to date technically in some necessarily restricted area, which is good, it sometimes runs the risk of being a rather isolated piece of experience, making it difficult to extrapolate the benefits to more general problems in engineering education. On the other hand, how better to get a broad sample of the problems which young engineers face than by working very closely with them in solving these problems through a teacher-student relation? The faculty members will thereby encounter and become acquainted not only with the newest technical developments and problems

(the better to teach specific courses) but also derive a broader base of experience with the more general problems facing young engineers (the better to provide general advice and counsel for undergraduates).

In addition, the added challenges inherent in such a situation make it particularly attractive to some teachers. There are many aspects of teaching in the typical academic environment which teachers view with mixed emotions. What teacher has not felt that his students were working for artificial goals such as grades, honors and awards, or simply to get by, viewing each course as another obstacle which a sadistic administration has placed in the way of that all-important diploma? Students are seldom self-motivated because it is hard for them to sense the relevance of what they happen to be doing to what they will be doing after graduation.

Do Quizzes Help?

The student sees the periodic quizzes and examinations not as a means of self-evaluation of progress, but as so many pedagogical traumatic experiences. Then, too, the sections are frequently much too large for effective personal contact with the individual student and his difficulties. And if, perchance, some class develops a high interest in some particular topic and is anxious to explore it in greater detatil, the teacher is cast in the role of a "cold water merchant," forced to quench the coals of curiosity because, he still realizes that his course is a prerequisite to others and he must cover certain material in fairness to his colleagues. And, finally, the students are to a certain degree a captive audience, relatively incapable of communicating effectively to the right people their praise of the superior or criticism of the mediocre teachers. They go to the good and fair teachers alike, for they have few alternatives.

Fancy now if you can a situation less encumbered by these obstacles to true learning. With a little imagination and resourcefulness, would it not be possible for short courses in industry to make great strides in shucking off these impediments? Now employed, the students could be self-motivated, responsible for evaluation of their own progress and could come if the teacher was effective, could avoid him if not. Individual attention could be given to each student's unique educational needs. It sounds almost too good to be true! Surely a teacher would find such summer experiences invigorating!

So let us have more of these flexible and versatile summer courses in industry. It seems that they could both provide immediate returns and enhance the long-range professional development of the young engineer. They could be a way for some types of companies to profit technically while discharging their responsibilities to their young employees. Finally, such courses could provide very valuable experience for the teacher to take back to his college or university work, providing him with an atmosphere in which he could charge his educational batteries to withstand the steady drain of the typical college session. This kind of busman's holiday for engineering teachers ought to be more clearly recognized and exploited as an important, rewarding, useful, and profitable form of summer work for college faculties. H. A. F.

TEACHING POSITIONS AVAILABLE

ASSISTANT PROFESSOR OR INSTRUCtor to teach fundamental Electrical Engineering courses in Midwest Engineering College. M.S. degree or teaching experience desirable. Position available January 1, 1956 or later. Good salary for qualified person. MAR-2

PROFESSOR OF HEAT POWER OR Fluid Mechanics, interested in assuming department headship; experienced teacher, doctor's degree preferred. Wanted by eastern metropolitan ECPD-accredited college for September, 1956, or sooner if available. MAR-3

ENGINEERING FACULTY OPPORTUnities at midwest college. Chairmanship of the Physics Department, salary open. Also opening for Electrical Engineering Instructor or Assistant Professor in Power Field. Mechanical Engineering Instructor or Assistant Professor in Heat Power and Engineering Mechanics. Instructor or Assistant Professor in Physics. Opportunity for graduate study. Housing available. Appointments to begin September, 1956. MAR-4

ASSISTANT, ASSOCIATE, OR FULL Professor (rank depends upon training and experience) to teach Chemical, Civil, Electrical, and Mechanical Engineering courses. Individuals who desire to do research as well as teaching are desired. Opening September 1, 1956, or sooner. Location Southeast. MAR-5

ASSISTANT PROFESSOR AND INSTRUCtor at growing midwest engineering college in Department of Mechanical Engineering, effective fall semester 1956–57. Assistant Professor must have special experience or training in machine design. Teaching assignment for instructor would include: Heat-Power, Manufacturing Processes, and Laboratory. Salary in both grades dependent upon qualifications. MAR-6

INSTRUCTOR OR ASSISTANT PROFESsor to teach Electrical Engineering courses in a southeastern university. Instructor may obtain M.S., for Assistant Professor M.S. required. Extra income for regular summer school. MAR-7

INDUSTRIAL ENGINEER NEEDED CApable of organizing and teaching Industrial Engineering on the undergraduate level in a regular Mechanical Engineering degree program. Should be active in teaching and professional organizations. Salary and academic rank depending upon degrees and experience. Location, Ohio. Appointment to begin September, 1956. MAR-8

HEAD OF OFFICE EXTENSION SERVices in the Institute of Technology, State College of Washington, Pullman, Washington. Rank of Associate Professor or equivalent, salary for eleven months. Appointment effective July 1, 1956. Additional information may be obtained by writing G. A. Riedesel, Secretary, Committee for Industrial Services, 159 Engr. Lab. Bldg., W. S. C., Pullman, Washington.

ASSISTANT PROFESSORS AND INstructors in Electrical and Mechanical Engineering wanted by the College of Engineering, Marquette University, Milwaukee 3, Wisconsin. Salary commensurate with qualifications. M.S. or work toward it desirable. Opportunity for part-time graduate work at state university. Please forward complete details of education, experience, and personal background to respective department chairmen.

HEADSHIP OF INDUSTRIAL ENGIneering department. Requires background of professionally responsible management position in industry or government, plus good record of publications. Research and teaching experience desirable. Age range 35–50; salary open; position to be filled before September, 1956. Write Chairman, Nominating Committee, Industrial Engineering Department, Pennsylvania State University, University Park, Pennsylvania.

ASSISTANT PROFESSORS, INSTRUCtors, Research Assistants, and Graduate Assistants needed in Engineering Mechanics. Excellent opportunities for graduate work. Write Joseph Marin, College of Engineering, The Pennsylvania State University, University Park, Pennsylvania.

ELECTRICAL ENGINEERING STAFF opening at Colorado A & M College, Fort Collins, fall 1956. Healthful climate, good schools. Expanding department, new building fall of 1957. Nine months appointment, rank and salary commensurate with qualifications. Write Head, Department of Electrical Engineering.

TEACHING POSITIONS IN ENGINEERing technology; teaching and industrial experience desirable. B.S. or M.S. degrees. Cooperative program—Physics, Mathematics, Engineering Drawing, Machine Design, Strength of Materials, Tool Design. Positions beginning September, 1956. Sinclair College, 117 W. Monument Ave., Dayton 2, Ohio.

ASSISTANT DEAN OF ENGINEERING, Master's degree preferred but not required. Salary to depend upon qualifications. Apply to: Dean W. A. Patterson, Fenn College, Cleveland 15, Ohio.

ENGINEERING MECHANICS AND Civil Engineering teachers urgently needed to begin about September 15, 1956. Write to J. H. Murdough, Head, Civil Engineering Dept., Texas Technological College, Lubbock, Texas.

SIX OPENINGS IN ELECTRICAL AND Mechanical Departments. Teaching Assignments: Electric Power, Electronics, Physics, Heat Power, Engineering Drawing, other Mechanical Engineering subjects. Salary depends upon qualifications. Excellent fringe benefits. M.S. in E.E. or M.E. desired. Applicants with B.S. considered. Write to Earle M. Morecook, Chairman, Applied Science Division, Rochester Institute of Technology, Rochester 8, New York.

ENGINEERING FACULTY MEMBER TO head newly authorized Electrical Engineering Department. Candidate should have M.S. or Ph.D. degree, with teaching and professional experience. Position to be filled before September, 1956. Salary open. Write to R. E. Gibbs, Dean, College of Engineering, Bradley University, Peoria 5, Illinois.

ENGINEERING DRAWING INSTRUCtor starting July or September, 1956. Ideal college town in the Rocky Mountains. Write to Head, Department of Mechanical Engineering, Montana State College, Bozeman, Montana.

ELECTRICAL ENGINEERING POSItion to teach undergraduate courses. M.S. required. Opportunity for graduate study, industrial consulting, or research. Rank and salary open. Start February or September, 1956. University of Santa Clara, Santa Clara, California.

MECHANICAL ENGINEERING POSItion open, Master's degree or higher, some teaching or industrial experience. Grade and salary dependent on qualifications. Nine months per year. Also Agricultural Engineering position to teach farm structures and machinery and power courses, as well as general engineering courses. Instructor or Assistant Professor rank. Salary commensurate with qualifications. Nine month appointment. Complete new Engineering Center under construction this spring. High and dry climate, no traffic or smog, good schools, lots of elbow room, not an A-bomb target. Write Dean of Engineering, Colorado A & M College, Fort Collins, Colorado.

TO CONDUCT INDUSTRIAL MANAGEment major in small college. Teach 12 hours including Industrial Management course; other courses depending on training, experience, and preference. Outside consulting allowed. Rank and salary according to degrees and experience. Send resumé to Robert J. Moore, Utica College of Syracuse University, Utica, New York.

CHRYSLER INSTITUTE OF ENGINEERing again has openings on its full-time teaching staff. For: supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork. Desired qualifications are age 25–40; B.S. degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive. Also a teacher and supervisor of Graduate School classwork. Qualifications are age 25–40; M.S. degree in engineering; experience in teaching Mechanical Engineering subjects. Write to Chrysler Institute of Engineering, Att: L. R. Baker, Director, P. O. Box 1118, Detroit 31, Michigan.

INSTRUCTOR AND ASSOCIATE PROFESSOR positions open in Mechanical and Civil Engineering, beginning September, 1956. Rapidly growing school. Write to Executive Dean, Fresno State College, Fresno, California.

INSTRUCTOR AND ASSISTANT PROFESSOR in Engineering Drawing and Descriptive Geometry for September, 1956. Assistant Professor's rank requires Master's degree. Retirement age of 70 offers opportunity for additional years of teaching to those forced to retire elsewhere at 65. Apply to Dean James R. Cudworth, College of Engineering, University of Alabama, University, Alabama.

CIVIL ENGINEER—TO TEACH SURVEYING, Highways, Fluid Mechanics, Materials Testing, and Civil Engineering laboratories. Should have M.S. or Ph.D., be active in technical and professional organizations. Salary and rank open depending upon degree and experience. Position starts September, 1956. Location, Ohio. MAR-9

COMBINED TEACHING AND APPLIED Research positions in Physics, Electronics, and Mechanical Engineering. Contract research for industry and military. Ph.D. or M.S. required. Salaries comparable to industrial. Staff encouraged to develop own research project ideas for sponsorship. Write to Assistant Director, Denver Research Institute, University of Denver, Denver 10, Colorado.

CONSTRUCTION EDUCATION SUMMER SCHOOL

Ames, Iowa, June 29-30 and July 1, 1956

The Civil Engineering Division announces a Summer School on Construction Education in conjunction with the ASEE Annual Meeting at Iowa State College. Conceived as a device for giving impetus and direction to the growing interest in construction education throughout the country, this Summer School will bring together representatives of education and industry to exchange views and experiences and to develop programs of cooperation and action.

Friday Afternoon—Construction Industry Presentation

Contractors Look at Engineering Education
What Contractors Expect of Engineering Graduates
Summary of the "National Conference on Construction Operations" held in Los Angeles in January, 1956

Friday Evening—What Education Framework?

Construction Option in Civil Engineering
Construction Option in Architectural Engineering
Construction Engineering Curriculum
Graduate Study in Construction
Technical Institute Program

Saturday Morning—What Special Subjects

Methods and Equipment
Costs and Estimates
Construction Planning and Management

Saturday Afternoon—How Can Industry Contribute?

How AGC Chapters Can Assist the Engineering Colleges
How Building Contractors Can Help
Panel Discussion

Sunday Morning—General Discussion

Needs of Construction Industry for Engineers
Challenge to Engineering to Embrace the Field of Construction Management
What Special Construction Education is Needed?
What New Developments Will Influence Tomorrow's Construction?
How Can the Construction Industry Best Aid and Guide Students and Faculties?
What Are the Needs for Methods Research?

Recess for Church

Sunday Afternoon—Consideration of Resolutions

Resolutions Committee to introduce resolutions expressing consensus of delegates on important points

Discussion and action on resolutions

Speakers and discussion leaders include outstanding persons from the construction industry and from construction engineering education.

The program has been developed by Committee 6, Construction, of the Civil Engineering Division of ASEE, under the Chairmanship of C. Martin Duke, Professor of Engineering, University of California, Los Angeles. Committee members are H. B. Blodgett, University of Nevada; A. N. Carter, Associated General Contractors; A. L. Chambers, University of Kentucky; Ellis Danner, University of Illinois; E. E. D'Appolonia, Carnegie Institute of Technology; P. F. Keim, University of California at Berkeley; J. A. Oakey, North Dakota Agricultural College; J. J. Kennedy, N. O. Naval Base, and W. T. Hosmer, Iowa State College.

Details of the sessions and arrangements will be given in the *Civil Engineering Bulletin*, and in the final program of the annual meeting.

NEW MEMBERS OF THE ASEE

ARGES, K. PETE, Assistant Professor of Civil Engineering, Duke University, Durham, North Carolina. Edward K. Kraybill, Paul C. Stottlemyer.

BALL, LLOYD D., Instructor Engineering Drawing and Machine Design, University of Colorado, Boulder, Colorado. C. L. Eckel, F. S. Bauer.

BANNON, ROBERT E., Associate Professor in Metallurgy, Mechanical Engineering, Newark College of Engineering, Newark, New Jersey. G. B. Thom, I. P. Orens.

BARNES, EDWARD M., Associate Professor, School of Technical Training, Oklahoma A. & M. College, Stillwater, Oklahoma. H. P. Adams, Hugh Lineback.

BAXTER, WYLEY L., Associate Professor in Graphics, United States Air Force Academy, Aurora, Colorado. James S. Barko, Archie Higdon.

BISSIRI, AUGUSTO, JR., Instructor of Engineering, Los Angeles City College, Los Angeles, California. B. W. Martin, A. L. Eller.

BLACK, LOREN T., Instructor of Mathematics, Long Beach City College, Long Beach, California. D. M. Wilson, D. L. Trautman.

BOND, ROBERT EDWARD, Assistant Professor in Drawing, College of Technology, University of Houston, Houston, Texas. Joseph A. Bennett, Charles P. Hayes.

BRANDENBURG, PATRICK FISK, Assistant Professor of Mechanical Engineering, University of Wichita, Wichita, Kansas. John W. Dunn, L. U. Rastrell.

BRANDS, FRANK WILLIAM, Instructor in Electrical Engineering, Washington State College, Pullman, Washington. E. G. Ericson, A. L. Betts.

BRINKMANN, THOMAS HENRY, Assistant Professor in Industrial Relations, Northwestern University, Evanston, Illinois. C. E. Watson, P. W. Erb.

BROWN, ELLSWORTH ALLEN, JR., Instructor of Mechanical Engineering, Northwestern University, Evanston, Illinois. R. L. Young, E. F. Obert.

BULLIS, WILLIAM R., Instructor of General Engineering, Hartnell College, Salinas, California. C. E. Cherry, D. L. Trautman.

BURGER, WILLIAM, Dean of Students, Colorado School of Mines, Golden, Colorado. F. R. Campbell, William J. Chapitis.

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106 new members
275 previously added
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381 new members this year

Professor Emeritus **John Clayton Tracy** of Yale University, a member of the ASEE since 1907, died November 1, 1955, in New Haven, Connecticut, at the age of 86. After graduating in 1892 with PhB and CE degrees, he began teaching in the Yale Civil Engineering Department and continued until his retirement in 1936. For 21 years head of the Department, he reorganized both Engineering Drawing and Engineering Mechanics courses. His major contributions to engineering education were made in changing the Sheffield Scientific School from a three-year to a four-year program, and in establishing first a division and later a separate School of Engineering at Yale. Professor Tracy was a Life Member of the ASEE, and member of the General Council 1912–1915 and 1920–1923.

MATHEMATICS IN ENGINEERING

Report of Pasadena Conference

The recommendations given below are the results of an exploratory meeting held on November 28–29–30, 1955. The topics agreed upon will be developed further at an open Summer Institute conference, sponsored jointly by ASEE and the National Science Foundation, to be held at the University of Michigan, Ann Arbor, on June 20–21–22, 1956.

The present rapid developments in the various engineering disciplines are bringing both the research and design engineer into an increasingly intimate contact with new and diverse fields of the mathematical sciences. Since this trend promises to increase steadily with future engineering advances, the role of mathematics in the engineering educational program should be under continual assessment.

A preliminary evaluation of the role of mathematics in engineering was made by a group of 22 engineers and mathematicians at an invitational conference held in Pasadena, California, on November 28, 29, and 30, 1955. This closed conference was sponsored jointly by the American Society for Engineering Education and the National Science Foundation, in cooperation with the California Institute of Technology and the University of Michigan. The organization was effected by a planning committee consisting of Dean George Granger Brown, University of Michigan, Co-Chairman; Dr. Richard S. Burington Bureau of Ordnance, U. S. Navy; Professor Paul F. Chenea, Purdue University; Professor Howard W. Emmons, Harvard University; Dr. George H. Hickox, National Science Foundation; President William V. Houston, The Rice Institute; Dr. Hillel Poritsky, General Electric Corporation; Professor F. C. Lindvall, California Institute of Technology, Chairman.

The participants were chosen by this committee to give as wide a representation of the different engineering and mathematical fields as possible from the academic, research, and industrial points of view. The agenda for the three full days of round-table discussions drawn up by the planning committee included four broad topics:

(a) An interchange of ideas among the engineers on the mathematical trends and requirements in their respective fields.

(b) A review of the interplay between mathematics and engineering, with an evaluation of the role that several new fields of mathematics might come to play in engineering.

(c) Consideration of the present and future mathematical content and philosophy for both undergraduate

and graduate curricula in engineering.

(d) Broad planning of a general open meeting to be held at the University of Michigan in June, 1956, under the joint sponsorship of ASEE and the National Science Foundation to amplify the conclusions reached under items (a), (b), and (c).

Michigan Meeting

The general plan evolved by the conferees for the meeting at the University of Michigan, Ann Arbor, in June, 1956, provides for between six and eight half-day sessions. The sessions will be devoted to the following areas: probability, statistics, numerical analysis and computers, systems analysis and synthesis, and continuum mechanics.

Typical sessions will consist of two invited addresses by outstanding speakers, one of whom is primarily interested in the mathematical aspects of the particular topic, while the other is primarily concerned with the use of that particular field in engineering. The program is designed to stress those areas of mathematics which are finding new uses in engineering, and will emphasize the interaction of the disciplines of mathematics and engineering. It is also hoped that at least one session will be devoted to a panel discussion concerned with the impact of these new fields of mathematics on education for science and engineering students.

The Role of Mathematics in Engineering

In general, it can be said that there are three principal facets of mathematics as applied to the engineering sciences:

(1) The use of mathematical language, structures, and concepts in the expression and formulation of the basic physical laws upon which engineering rests.

(2) The distillation of complex engineering systems and physical phenomena into mathematical models which are descriptive of the engineering systems, and which therefore may be suited to quantitative analysis.

(3) The use of mathematical techniques to carry out quantitative analysis in established models.

It is true that an engineer employs mathematical knowledge and techniques to widely varying degrees, depending on the level of sophistication and needs of his particular work. Nevertheless, it was felt that since the scope of mathematics applicable to engineering is expanding so rapidly, all engineers should possess sufficient "mathematical literacy" to determine more or less in what category difficulties may lie, to know when to turn to a specialist for advice, and to be able to communicate effectively with such persons.

New Fields of Mathematics in Engineering

Certainly classical fields of mathematical analysis such as differential equations, function theory, and the calculus of variations are widely employed in engineering. Moreover, much research remains to be done in these fields, both by the mathematician and engineer, particularly toward the understanding of various phases of nonlinear phenomena in continuum theory.

Despite this, most conferees were more concerned with the appearance of entirely new fields of mathematics in engineering science over the past two decades. The field of mathematical

statistics has become an important adjunct for both the design and test engineer. Probability and the theories of statistical estimation are also finding increasingly significant applications in the fields of guidance and control. The theory of probability, with particular emphasis upon stochastic processes, is now the basis of much of the work in modern electrical and communications design.

The use of probabilistic and statistical models to describe complex engineering systems and to formulate design criteria for such systems is becoming increasingly widespread. The wartime operations research and the former engineering "common sense" have evolved to include broader mathematical structure (e.g., linear and nonlinear programming, theory of games) which has led to certain broad scientific principles for analyzing and synthesizing exceedingly complex engineering systems.

Finally, the advent of high-speed computing machines has given the engineer an important tool, both for engineering analyses and syntheses. It has also given rise to fresh developments in the mathematical field of numerical analysis. In the applications of numerical analysis and computing machines, many of the conferees expressed apprehension about the present and future misuse of high-speed machines, because of the lack of mathematical background and literacy on the part of engineers and applied scientists.

The Teaching of Mathematics to Engineering Students

The calibre and continuity of the high school mathematics preparation are basic to any discussion of the mathematics program for engineering students. The conferees were not willing to accept a policy of lowered admission standards, with remedial work as part of the normal college program. Rather, it was believed that engineering colleges should insist that those students who wish to complete their training in the normal time must come prepared to start a course in calculus and analytical geometry at the beginning of their freshman year. For this, a sound training in the bulk of the material usually covered in a two-year high school algebra course is needed, as well as analytic trigonometry, the basic ideas of plane geometry, and a small amount of solid geometry.

It was also noted that several leading engineering schools no longer required solid geometry for entrance, and that many others are dropping this requirement. It was felt that the usual year spent in plane geometry has not been effectively used and that the course in trigonometry should emphasize the analytical aspects of the subject, with comparatively little emphasis on "solving triangles."

It was considered important that those high school students expecting to major in science or engineering in college should take mathematics throughout their entire last year in high school, as continuity of effort between secondary school and college is exceedingly important. A gap of a year without mathematics seriously handicaps a student who must compete with classmates who are freshly prepared. It is suggested, therefore, that wherever possible high schools should offer four years of mathematics, with the first three-year sequence revised along the lines indicated above. The fourth year could then contain additional algebra, coordinate

geometry, and some elementary calculus. For adequately staffed high schools, too, a college-type course in calculus and analytic geometry could be offered to replace the first year college course.

The objectives of mathematics training in college are threefold:

(1) to give an understanding of the structure of mathematics;
(2) to give an understanding of the interrelation of mathematics with engineering problems;
(3) to develop manipulative skills.

It is primarily the function of the mathematician to give the student some understanding of the nature and structure of mathematics and how mathematics differs from experimental science. The second function is carried out by instructors in science and engineering, who show how problems of science and engineering are formulated in mathematical language, and how the results of solving the mathematical problem are interpreted physically. Manipulative skills can and should be developed in all courses which use mathematics.

With the limited time available in the undergraduate engineering course, and the increasing demand for additional subject matter, it is essential that close liaison be maintained between instructors of mathematics, engineering, and science courses. This liaison should not be confined merely to knowing the topics taught in various courses. The mathematicians must be conscious of the way in which engineers will need to use mathematics, and engineering instructors must understand the point of view of professional mathematicians. In the same way, instructors in the various branches of the engineering sciences must maintain equally close liaison with each other.

Further, experience has shown that a significant number of engineering graduates have forgotten their basic mathematics. Only by continued use can mathematics be made a part of the engineer's effective equipment. Engineering instructors are urged to make maximum use of the students' mathematical preparation in junior and senior engineering courses, as well as accepting the responsibility of introducing new mathematical topics as needed.

Report of the Curriculum Subcommittee (Bowker Committee)

Early in the conference, a subcommittee was chosen to formulate an ideal mathematics curriculum in engineering. Their report follows:

The general trend toward the use of more mathematics in engineering will unquestionably result in additional mathematics courses in graduate and undergraduate curricula. In view of the heavy work load in engineering programs, it is not feasible to recommend any general increase in the number of courses.

Most of the recommendations take the form of elective courses, with the expectation that many areas of engineering will find it desirable to suggest or require them, and adjust other items in the curricula accordingly. An ideal solution would be to include some first year mathematics in the secondary school program, perhaps even a year's college level course in calculus and analytic geometry, and to use the time thus created in the engineering program for additional mathematics.

In addition to specialized advanced courses in the branches of mathematics

important for engineering, the introduction of new material in the basic calculus courses should be under constant consideration. It is difficult to see how much material on statistics can be included, particularly in view of the desirability of close coordination between beginning courses in mathematics and physics.

There are, however, several opportunities in elementary calculus to introduce and stress numerical methods, and these should be fully exploited. As a matter of fact, all applied courses in mathematics should take account of the growing use of mechanical and electronic computers and should put increasing emphasis on numerical techniques.

The single course beyond calculus that we feel should be required of all engineering students is a one-semester course in differential equations. A rudimentary knowledge of differential equations is essential to an understanding of physical laws and is the logical capstone of the calculus. Since this course may be terminal for some students, it should contain enough discussion of the general nature of differential equations to permit a student to identify linear and nonlinear types and to distinguish ordinary from partial differential equations.

It should concentrate, however, on linear ordinary differential equations with constant coefficients (and perhaps include the corresponding difference equations). It should introduce, both as a pedagogical and practical device, some of the standard numerical techniques, which may necessitate the elimination of material on formal integration of special nonlinear types often found in courses at this level. In teaching this course it is important to emphasize the translation from physical to mathematical problems and to interpret the solutions of the differential equations in terms of physical problems.

It is desirable that the students be prepared to take calculus in their freshman year and that they should acquire in secondary school an adequate background for this purpose in algebra, trigonometry, and the use of coordinates. In these circumstances the differential equations course could come in the sophomore year, but, in any case, it should follow calculus immediately.

After differential equations, the next priority should be given to a one-semester course in introductory statistical analysis. Some calculus should be prerequisite. It is the thinking of the Committee that this course will be required of an ever-increasing number of engineering students. Topics would include basic statistical notions: random variables and distribution functions, the general concept of statistical decision-making, standard significance tests and estimates, and an introduction to experimental design. Some material on quality control and sampling inspection should be included.

Our third recommendation is that the mathematical curriculum contain a two-year elective sequence in applied analysis for engineers. Ordinarily a student would take one year as an undergraduate and the second during his first graduate year. The topics in this sequence would include (in some order) vector and tensor analysis, matrices, partial differential equations, special functions, boundary and initial value problems, complex variables, integral transforms, integral equations, and variational calculus.

Two patterns seem to emerge for organizing this material into a two-year sequence. The first starts with a one-year course in advanced calculus for engineers based on one of the standard textbooks, in which almost all the topics listed above are mentioned. The objective of this course is to provide students with mathematical literacy by acquainting them with a variety of mathematical concepts and techniques. The second-year course would then contain a more detailed discussion of some of the same topics.

An alternative pattern is to have separate courses devoted to (1) vectors, tensors, matrices, (2) partial differential equations, (3) complex variables, (4) integral transforms and related topics. The objective here would be to provide a more detailed discussion of individual topics than is possible in a one-year composite course, and to emphasize the development of mathematical ability as opposed to a broad acquaintance with mathematical topics.

A further recommendation deals with the establishment of three one-semester elective courses dealing with newer areas which we believe are likely to be important in the future.

These courses are:

1. Modern computing possibilities, which would include some material on numerical analysis, some on the mathematization of engineering problems, and some on the nature of machine capabilities.

2. Probability theory for electrical engineers, physicists, and possibly for industrial engineers interested in operations research. The course would be at the same level of mathematical sophistication as probability courses frequently offered as part of a one-year sequence in mathematical statistics. For engineering purposes, emphasis on combinatorial probability, finite problems, and manipulations with densities should be reduced in favor of presenting material on discrete and continuous stochastic processes.

3. Maxima and minima of functions for several variables under various kinds of restraints, including systems of linear inequalities. It would contain an introduction to linear programming, as well as its extensions and applications in engineering or logistics. Such a course might be labeled "Optimization in Multicomponent Systems."

The exact outline of these courses is something which needs to be worked out. Except perhaps in the computing field, no standard courses of this sort have come to the attention of the Committee.

The final recommendation is that funds should be found to support well-conceived curriculum construction and experimental textbook writing programs in these three fields.

The following participated in the closed conference on the Application of Mathematics to Engineering: A. H. Bowker, Stanford University; Richard S. Burington, Department of the Navy; Paul F. Chenea, Purdue University; Stephen H. Crandall, Massachusetts Institute of Technology; Howard W. Emmons, Harvard University; W. L. Everitt, University of Illinois; George E. Hay, University of Michigan; F. C. Lindvall, California Institute of Technology; R. F. Mettler, Ramo-Wooldridge Corporation; Morris Ostrofsky, Westinghouse Research Laboratory; Hillel Poritsky, General Electric

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HUMANISTIC–SOCIAL SUMMER SCHOOL

Sponsored by: Humanistic-Social Division of ASEE
Dates: June 28–30, 1956
Theme: How Can Humanistic-Social Courses Be Taught Most Effectively?
For information write: Melvin Kranzberg, Associate Professor of Social Studies, Case Institute of Technology, Cleveland, Ohio.
Iowa State Coordinator: James Humphrey, English and Speech Department, Iowa State College, Ames, Iowa.

This program, based on and developing from the *Report of the Humanistic-Social Research Project*, is focused on *specific courses* and *how* these are actually taught in the classroom. Each speaker will describe the course he offers, discussing (1) objectives, (2) content and organization, (3) reading assignments, (4) teaching methods, and (5) effectiveness of the course as given. The program will be of special interest to those engaged in teaching similar courses and to engineering educators concerned with fresh departures in teaching the humanistic-social stem.

Thursday, June 28

Afternoon: History of Science Courses
Henry Guerlac, Cornell University
Carl W. Condit, Northwestern University
Thomas M. Smith, California Institute of Technology

Friday, June 29

Morning: Psychology Courses
M. Carr Payne, Jr. Georgia Institute of Technology
James T. Freeman, Iowa State College

Afternoon: Western Civilization Courses
Louis Furman Sas, The City College of New York
John P. Fife, Stevens Institute of Technology

Saturday, June 30

Morning: American Civilization Courses
Alfred D. Chandler, Massachusetts Institute of Technology
Reginald C. McGrane, University of Cincinnati

THE ROLE OF PHYSICS IN ENGINEERING EDUCATION

The AIP Report—Editorial Note

For several years, calls have been heard and preliminary steps taken toward a re-examination of the relationship between physics and engineering instruction. This need was recognized by the ASEE Committee on Evaluation of Engineering Education, which requested the American Association of Physics Teachers and through them the American Institute of Physics to study the matter. A committee was appointed, and its final report is given in full below. Through the courtesy of Dean Elmer Hutchisson, Chairman of the AIP Committee, and of Editor Robert R. Davis of *Physics Today* (which presented the report in December for the physics group) concurrent publication has been made possible for the ASEE.

The Report of a Committee of the American Institute of Physics

THE REPORT IN BRIEF: The role of physics in engineering education is not a static one. It must respond and evolve with the momentous changes in both engineering and physics which are occurring continually. The predominant reliance of early engineering upon art is giving way to a modern technology based squarely upon the physical sciences. Since the beginning of this century we have seen as much progress in physics as had been obtained in the whole previous history of mankind. Yet the obvious and enormous increase in subject matter of modern physics is not the most significant factor relating to the aim of instruction in physics in the education of engineers. On the contrary, the cardinal aim should be that of imparting to the student a point of view, an attitude of mind, and a capacity to deal with the principles and methods of analysis of contemporary physics, for, without training and experience in these modes of thought, neither physicist nor engineer will prove competent to deal with the emerging problems of science and technology.

In the interest of instilling this point of view with respect to basic principles and to the mastery of methods of approach, the Committee makes the following recommendations which are discussed in detail in the report:

1. Improved communication between engineers and physicists at the institutional level to discuss objectives and determine mutual needs.
2. Early contact of engineering undergraduates with physics.
3. Increased participation of research-minded professors in undergraduate teaching.
4. Introduction of more challenging experiments in laboratory instruction.

5. Greater emphasis, particularly in textbooks of general physics, on ideas, principles, and methods.
6. More appropriate use of mathematics in general physics teaching.
7. Greater encouragement of experimentation in teaching.

Foreword

Presented herein is the final report of a committee established in December 1954 by the American Institute of Physics to study the role of physics in engineering education and to recommend ways of making the teaching of physics in engineering as effective as possible. This committee had its genesis in a request made to the American Association of Physics Teachers (AAPT) by the Committee on the Evaluation of Engineering Education of the American Society for Engineering Education (ASEE), which was appointed in 1952. The ASEE committee has been studying the patterns needed in engineering education to keep pace with the recent rapid developments in science and technology. In this study, the Committee on Evaluation recognized that physics deserves special attention and made a request of the AAPT to appoint a committee for this purpose. In considering this problem, the AAPT concluded that the problem was so broad and of such importance that the American Institute of Physics, representing all physics in America, should be asked to set up the proposed committee. It was expected that the Institute's committee would study and make full use of the results of the joint conferences between engineers and physicists, which had been or were being held on nuclear and solid-state physics, mechanics, thermodynamics, and electrodynamics under the sponsorship of individual universities, the ASEE, and the National Science Foundation. The present Committee was appointed and asked by the Institute to evaluate the teaching of physics in engineering education and to recommend means by which physics teachers could make the maximum possible contribution toward developing the kind of engineers that are needed in the complex civilization in which we find ourselves.

To obtain first-hand information in carrying out its work, members of the Committee in pairs visited 26 representative colleges offering engineering programs and discussed the physics courses within these programs with members of the staffs of both the engineering and physics departments. In addition, questionnaires were sent to the physics departments of essentially all engineering colleges asking for detailed information on the physics courses offered in these schools. Reports of these visits and the replies to the questionnaire, as well as reports of the joint conferences mentioned above, were studied by the members of the Committee. The present report has resulted from two extended meetings of the Committee and from critical discussions on the part of interested engineers.

The Committee takes this opportunity of expressing its deep appreciation to the National Science Foundation for its interest and financial support and to the many engineers and physicists who have given so much of their time in assisting the Committee in obtaining the factual information upon which the recommendations included in this report are based.

The members of the American Institute of Physics Committee on the Role of Physics in Engineering Education are

the following:

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I. *The Changing Scene in Physics and Engineering*

Physics and engineering have undergone revolutionary changes during the past century both in their individual development and in their interaction one with the other. The ability of man to profit by and to build on the experiences of the past and to join together in organized cooperative groups has permitted a great expansion of our knowledge and understanding of Nature and also the development and construction of complex machines and structures far beyond anything which would be possible through the ability of any one individual.

The early physicist worked with relatively simple equipment and with concepts based primarily upon his mechanical experience. As a rule he worked with no or few assistants in a small laboratory or at a desk. With such simple resources he discovered the electron, x-rays, and radioactivity and thus opened the door to a flood of new discoveries which are still being announced at an ever-increasing rate in this twentieth century. These new discoveries have been the foundation of entire new industries. The physics of electron flow utilized in the vacuum tube brought forth the vast electronics industry with applications to radio, television, automatic control, and radar. Nuclear fission has resulted not only in new weapons of destruction but in a new power industry as well. These new industries in turn have provided the physicist with powerful new tools, not only to explore the atom, but through improved instrumentation to revive and to accelerate advances in such classical fields of physics as mechanics, thermodynamics, acoustics, electrodynamics, and optics.

Today, although still depending greatly on individuals with deep insight, much of the progress of physics occurs through the strength of organized effort. The physicist draws on the immense resources of other branches of science and of engineering to do his part in advancing understanding and knowledge which at an ever-increasing rate provide new opportunities for engineering application.

The early engineer practiced his profession of building roads, bridges, buildings, as well as "engines" of war, on the basis of empirical knowledge and experience, passed down from generation to generation. Engineering was chiefly an

art with little relation to the science of the time. The ingenuity and talent of these early engineers are evidenced by the great cathedrals, water systems, bridges, and many other structures which are still standing.

Gradually the projects taken on by the engineer widened in scope and complexity and gave rise to an important change in man's way of life, known as the industrial revolution. The engineer built machines to convert the stored-up energy of fuels into useful mechanical energy. Again, much empirical knowledge was gained, but the engineer began to utilize new scientific discoveries and scientific methods of investigation, seeking to establish a rational basis for engineering decisions. New and difficult engineering problems were analyzed into their component scientific problems; the solution thus obtained expanded manyfold the engineer's ability to cope with the increasingly complex requirements of our civilization for machines and structures.

What of the future? In what direction will engineering advance and what kind of emphasis is needed in engineering education to prepare young men to take full advantage of new knowledge being uncovered? These are difficult questions but there are a few guide posts. We do know, for example, that man's power requirements are at least doubling every decade. There is every evidence that this growth in demand will continue and that the engineer will be faced with the necessity for exploiting every possible source of energy to take care of the world's insatiable demand for power. He will need not only to find ways of converting energy from one form to another more efficiently, but will also have to be able to develop new sources of energy such as that from the nucleus, the sun, and possibly even from the waves or the wind.

As a second general guide, it seems inevitable also that man will be demanding continually more delicate and more rapid methods of controlling power. Automatic methods will pervade all branches of engineering. The civil engineer will use automatic methods in tasks ranging from surveying to the great movements of earth and steel that are needed in modern construction. To a greater and greater extent, factories will be automatically operated. The high-speed electronic calculator will supersede the slide rule and, in many cases, elements of the human thought process itself. Inevitably the sanitary, chemical, and metallurgical engineer and all other engineers will rely more heavily on science. The pace of scientific and engineering achievement is now such that obsolescence is a major consideration. Often, the engineer must embark on a long-range project which may be rendered obsolete by ideas or devices now only in the earliest stages of discovery or development. He will make the best decisions who can best evaluate the possible scientific competition.

The physicist in his quest for knowledge often may confine his study to one problem at a time, but the engineer must solve all problems in one integrated design synthesized from his knowledge of many disciplines. The engineer may be called upon to complete a task for which existing knowledge is incomplete or inexact; here he must rely upon judgment based upon long experience. But as knowledge increases and engineering becomes based more squarely upon physical science, the greater the scientific grounding of the engineer, the better his engineering achievement.

Teachers of physics and of engineering, in turn, must adjust their teaching to these continuing changes in physics and engineering. The engineer dedicates his life to improving man's physical well-being and health. His is a creative profession and requires men of ingenuity, resourcefulness, and imagination. The engineer needs a broad understanding of the fundamentals of physics and other sciences whether they have immediate

application or not. He must be able to grasp the implication of new discoveries and the developing concepts of nature and be able to respond to the enthusiasm and stimulation of the creative scientist. Also, he must have knowledge of the course of history and be well trained in the art of receiving, interpreting, and communicating ideas to others. Yet, he must be taught that the engineer is a man of action, a doer, and a builder. To assist in training young men who can carry on these important tasks, the physicist and the engineer must work continually as partners in engineering education.

II. *Physics as it is Now Taught*

As was mentioned in the foreword, the members of the Committee are convinced that a report of this kind to be meaningful must be based upon first-hand information gathered through actual visits to engineering institutions and on-the-spot discussions. The following paragraphs summarize the information obtained from such visits and give a reasonably complete picture of physics as it is now taught in engineering colleges throughout the country. Numerical statistics are given in the Appendix.

The time devoted to physics in the engineering curriculum varies over wide margins. In several strong institutions two years are devoted to a general physics course amounting to as much as 17 to 20 semester hours. In many cases the time assigned to physics has been substantially increased over the past decade and there is an apparent trend in this direction. Nevertheless, the program of physics most commonly found in engineering colleges is a course of 8, 10, or 12 semester hours. The courses with the smaller numbers of credit hours often start in the sophomore year. Three-fourths of the colleges visited or those who replied to the questionnaire fall into this category (see Appendix A).

Mathematical prerequisites for physics vary from none except those required for admission (usually not less than higher algebra in high school) to one or two semesters of calculus. Simultaneous registration in calculus is required in about one-half of the schools from which data were obtained.

Atomic physics or so-called "modern physics" included in the general course averages about 10 per cent of the course. However, there is some evidence that if the numerous up-to-date examples of first principles cited in the several main divisions of physics, but not set apart as modern physics were included, the quoted percentages would be increased. In a few cases the time definitely devoted to modern physics is as much as 25 to 30 per cent.

Two or three hours per week are generally devoted to laboratory work throughout the physics course. Deviations from this pattern are in the direction of less laboratory. Laboratory sections are taught in nearly all schools by graduate assistants under supervision of senior staff members. Lectures are always given by senior staff. Recitations are generally under the direction of mature staff members and are taught both by experienced teachers and advanced graduate assistants. In a number of institutions, a critical study of laboratory instruction is taking place and already several basic changes have occurred which will greatly improve the effectiveness of laboratory instruction.

The objectives of the elementary course as described by the majority of the physics departments are, with only a few exceptions, the teaching of the most general basic physical laws and conservation principles. A fraction (approximately 20 per cent of those visited) emphasized problem-solving and the preparation of students for later engineering

courses. The historical development of science, the presentation of the scientific method, the coordination of mathematics, understanding of physical laws and engineering applications were also mentioned. Unfortunately, too often, the objectives had not been clearly thought through and there had not been enough discussion of these objectives with engineering staff members.

Generally, the engineering departments, when asked, agreed with the first of the above objectives. They wish the elementary physics course to be taught as a self-sufficient scientific discipline without special emphasis on engineering applications except possibly as these are used pedagogically as motivation devices.

An interesting trend is noted in a number of institutions. In some this is represented by new courses under a distinctly new curriculum called Science-Engineering (or Engineering Science) which does not carry the designation of one of the usual engineering divisions. In others, the student is permitted to substitute physics courses for technical engineering courses, thus qualifying him for a science major under one of the usual engineering degrees. In contrast to this trend, in one institution, most of the work in general physics is taught by engineering departments.

III. *A Brief Appraisal of Present Courses*

In the preceding section we have a brief factual view of the physics courses being taught. The important question is, of course, "Are they being well taught?" As with many questions the answer must be both "Yes" and "No." In some institutions physics is very well taught; in others it certainly borders on the inadequate. Also there are parts of some courses which are very well taught and other parts which certainly could be improved. This section of the report attempts to appraise frankly the good features as well as some of the shortcomings of physics courses now being given.

There is widespread dissatisfaction among both physics and engineering faculties with the encyclopedic coverage of the general physics course. This characteristic is often attributed to the extensive coverage of texts even though the teacher could, if he chose to do so, delete large sections from most texts. The desire is frequently expressed for a text with inclusion of basic principles and a minimum number of relevant but unnecessary materials and illustrations. A widespread opinion exists also that the physics program for the engineers should include more atomic, nuclear and solid state physics and that to an increasing extent examples from modern developments in physics be used in the general course. It must be recognized, however, that the amount that can be introduced into the general course will not be sufficient for the engineer whose professional life will extend over the next half century. To include more of the modern developments, there is a growing approval of an additional course, at least one term or semester in length, at approximately the junior level and suitable for the engineer who has completed the general physics course and the parallel mathematics.

In many institutions it is felt that the physics program is not assigned a sufficient fraction of the student's time. It was stressed that the one-year course which is often given is not sufficient for inclusion of the subject matter *all* engineering students should have. The newer topics, particularly, cannot be presented adequately within a one-year course. It is recognized that a reduction in the number of topics covered in the first year will help. But most physics

teachers and even many engineers are convinced that the gain will not be adequate to allow time for the inclusion of many present-day developments. At best the student will be left ill-prepared to comprehend these newer topics.

Unfortunately, the role of laboratory work in physics is often not clearly defined. It is interesting to note that sometimes engineers rated it more highly than the physicists did. If the objectives sought in the laboratory instruction are the development of techniques and the use of measuring instruments, the laboratory is generally considered to be successful. But if, as most teachers believe, it is to be an effective means of teaching principles, then improvement must be attained. The forward-looking experimentation now taking place will be watched with much interest.

Engineers and physicists alike deplore the poor mathematical preparation often obtained by the student in the secondary school. This situation necessarily lowers the mathematical level of basic freshman courses. In some schools an appreciable fraction of the students must take remedial mathematics, thus spending time that should be utilized for other purposes. In any case, it is recognized that the appreciation of mathematics as a physical tool must be supplied or at least be enhanced by the physicist.

In many institutions the members of the Committee found a great interest in, and really first-rate teaching of, physics for engineers. In others there is certainly room for improvement. Interestingly enough, improvements which the Committee would suggest and which form the basis for the recommendations in this report are not those which are sometimes mentioned in discussions between engineers and physicists. For example, there is no evidence of less interest today in expounding both the classical as well as the newer physics than existed decades ago. The great expansion of research in new fields has not caused the physicist to overlook the classical areas of physics in his teaching. In fact, this very expansion makes it imperative that from time to time we reexamine our teaching in terms of our present-day objectives. Only thus can we fulfill adequately our obligation to engineering education.

A large majority of engineering departments visited preferred to have the physics taught by the physics staff. In this way the student can best be exposed to the points of view and the methods characteristic of a basic science with its primary goal of understanding nature.

In a number of schools the engineers complain about the inadequacy of the preparation of the student who enters the first course in engineering mechanics, electricity, or thermodynamics. This may be an example of the almost universal complaint which is made at all levels that the previous training of the student is inadequate. Surely it can be helped by those teaching the advanced courses if they will take the necessary pains to assist the student in transferring to later courses the knowledge and understanding which he has gained from previous courses. However, to the extent that it is justified with respect to physics and engineering it may be due to uninspired teaching, poor organization, inappropriate texts, insufficient time, deficient preparation of the student, or a combination of all of these. If any of these are at fault then, indeed, do we have a common problem to be discussed between engineers and physicists and to be solved in a sympathetic and effective manner.

Communication between the various engineering departments and the physics department often is not adequate. It is generally agreed that both formal and informal meetings of all those staff members who are doing the teaching will provide an invaluable exchange of information of the course content and of the level of the performance of the students which is sought, expected, or actually attained. Such meetings are highly desirable and

will yield returns in a better curriculum and understanding of mutual objectives and problems. Such meetings do not presume a dictation of content of course material, nor of a method of teaching by one group for the other. Each department should be the final arbiter in its own realm but the increased knowledge and the comments of the others may give a better background for a decision. The appreciation by the physicist of his contribution to engineering would be enhanced by the exchange of points of view with engineers but it is not suggested that this lead to the teaching of engineering in the physics classes or to the teaching of physics in the engineering departments.

IV. *A Set of Goals for Physics in Engineering Education*

Perhaps the most important contribution that physics can make to the training of engineers is to provide a knowledge and appreciation for (1) the methods that have been found effective in describing the way nature behaves and (2) the concepts that have been derived therefrom. The body of physics as we know it today, which is considered essential to an understanding of these principles and concepts, represents the distillation and unification of knowledge gained over the past. The point of view of many physicists has been, and now is, that one should acquire an understanding of natural phenomena irrespective of any practical application. Such a view point has been eminently worthwhile since most modern technological developments are direct applications of many of these principles that were once considered academic and without practical use.

It is our belief that an increasing segment of the population and particularly those trained in technical fields should have an appreciation for the science of physics and the mode of thought which to such a large degree has been responsible for the phenomenal development of physics over the past decades. Specific contributions which the physicist can, by virtue of his training, make to the education of an engineer are:

(1) The physicist is, almost by definition, curious about the physical world in which he finds himself. It is hoped that some of this curiosity, and some of the satisfaction and enthusiasm resulting from increased understanding, will be imparted to his students.

(2) Along with understanding, the physicist also learns the limitation and scope of his descriptions and interpretations. These often are of a different character from those which the student meets in the solution of classroom problems in engineering and yet an appreciation of them is an essential part of an engineer's education.

(3) He has learned that there are underlying, unifying principles that can be rigorously expressed in mathematical terms and which are very general in their application. He has found these to be powerful tools in the expression and solution of important problems in nature. Examples of such principles are the laws of the conservation of energy and momentum which he teaches to his students with emphasis on where they apply and on their limitations.

(4) He knows that to appreciate fully the physics of today the student must know something of the historical development of underlying ideas, of the struggles of the past and the great strides that were taken by a few individuals in enunciating these broadly applicable unifying principles. We are firm in our conviction that all engineering students should know something of the origin of the knowledge which they will use so continuously.

(5) The physicist has often pioneered in the development of precise methods of measment. This he has done to understand nature better and to place his concepts on as firm a base as possible. Thus he, more than other men, has been interested in determining the fundamental constants of nature with the highest possible precision.

(6) The physicist believes that through a proper understanding of the laws of nature, people can arrive at more objective judgments and, it is hoped, keep free of many of the popular fears and superstitions involving science itself today. The history of physics has given ample proof that this can be done and certainly should be one of the objectives of a physics course.

(7) Lastly, a precise understanding of the basic concepts of physics is perhaps the best guarantee that the presently trained engineer will be able to contribute to the technology of tomorrow and herein lies one of the most important contributions the physics teacher can make in engineering education.

Only a partial achievement of the above goals can be expected in any single physics course under the best teacher. Certainly, a one-year course in general physics from a modern viewpoint, utilizing calculus as an essential aid, is hardly adequate. The trend away from too great a dependence upon the practical arts and toward the sciences in engineering practice makes it highly desirable to consider a two-year general physics course for all engineers. To teach properly the principles discussed above, the content of the general physics course must be carefully screened to eliminate much of the material of an engineering or applied nature. Furthermore, to achieve an understanding of and a feeling for the way nature behaves, a challenging set of laboratory experiments should accompany this general physics course. Routine "cook-book" experiments should be kept to a minimum.

We also recognize that one of the goals of physics instruction should be an introduction to the basic principles underlying atomic and nuclear physics and the solid state. The one- or preferably two-year general course must be regarded only as a preparation for introductory modern physics courses which may be given at the junior-senior level. A thorough understanding of nuclear and solid-state physics is achieved only through years of intensive study at the graduate level.

V. *Recommendations—a Program for Achieving the Goals Set*

In recommending a program aimed at more effective physics teaching in engineering education, the Committee recognizes that primary effort must occur at the local level and stem from within the colleges themselves. It is incumbent upon physicists to recognize the changing character and needs of engineering. The predominant reliance upon art is giving way to a modern technology based squarely upon the physical sciences, and this is reflected in the growing demands of the engineering profession for both a deeper understanding of fundamental principles and a broader introduction into recent advances. Physicists would do well to view these demands with sympathy and understanding and to accept them as a challenge to wider influence rather than as an invasion of vested interests.

It is no less important that the engineering profession and, indeed, physicists themselves take account of the evolving character of physics. The obvious and enormous increase in subject matter of modern physics is in our judgment not the most significant factor relating to the aim of the physics instruction in the education of engineers. On the contrary, we believe the cardinal aim to be that of imparting to the student a point of view, an attitude of mind, and a capacity to deal with the principles and methods of analysis of contemporary physics, for without training and experience in these

modes of thought, neither physicist nor engineer will prove competent to deal with the emerging problems of science and technology.

In the light of these comments we make specific recommendations under the several headings listed below:

1. Improved Communication

In each local institution members of the departments of physics and engineering should meet frequently together for free discussion in order that they may come to understand and appreciate more clearly their common interests and mutual needs. In some of the leading engineering schools it has been demonstrated that the contribution of physics, together with chemistry and mathematics, to the education of the engineering student can be greatly enhanced when the student clearly sees for himself that subsequent engineering courses draw upon the basic principles of the sciences and make use of the power of analysis developed from the point of view of the physicist. In these cases there is very little trouble with the problem of motivation. On the other hand, it is deadly from the standpoint of a student's motivation and morale if the engineering teacher assumes "a priori" that he must completely reteach his subject from the beginning even though it has been covered to a certain point in the basic sciences. It is urged, therefore, that teachers of engineering, wherever possible, provide an opportunity in their courses for the students to deal with engineering situations as best they can, using the understanding and methods obtained from the basic sciences. This cannot be done unless there is free exchange of information and views between the teachers of basic science and engineering; consequently, this constitutes one of many reasons why it becomes imperative to cultivate this close association.

2. Early Contact with Physics

We attach the utmost importance to instilling the point of view expressed earlier with respect to basic principles and to the mastery of methods of approach, and it is for this reason rather than any question of course content that we urge strongly that engineering students at an early point in their undergraduate careers be brought into an association with those who have made physics their life work.

3. Research-Minded Teachers for Undergraduates

Traditionally the home of research in the physical sciences has been the science departments of our colleges and universities. Much of the research that has led to the changing concepts and expanding scope of physics has been the work of members of the staff of such departments. Their research is essential to the continuing advance of science. The challenge of research promotes continuing vitality in those who engage in it and thus contributes to the development of science.

In recent years, however, there has been a growing tendency among some staff members engaged in research to neglect a basic responsibility which they share with the other members of their department, namely, the teaching of undergraduate students. This leads, we believe, to several undesirable effects.

Firstly, the high degree of motivation and inspiration which the successful research man can give is denied the undergraduate student.

Secondly, the undergraduate student is not provided with the high level of instruction which the research-minded professor is capable of giving.

Finally, such a professor, no longer required to refresh his understanding of the broad developments in physics, may tend to become increasingly narrow in his point of view.

In view of these facts we urge that consideration be given this problem to the end that all members of the staff, including those engaged in research, be encouraged to give instruction in physics to the undergraduate student. We firmly believe that in this way not only will the department provide the highest type of instruction in physics, but also the department will maintain its highest proficiency in research.

4. Laboratory Instruction

Since the fundamental laws and principles of physics provide the means of understanding many basic phenomena of nature, it is important that the student of science and engineering become acquainted first-hand with these basic phenomena in the laboratory and by means of well-chosen demonstration lectures. It is in the laboratory that the student comes into actual contact with phenomena in a basic way and, indeed, has the closest association with his teacher. Consequently, it is here that the teacher is presented with a great opportunity to aid the student in obtaining a clear and realistic understanding of basic physical principles. This opportunity should not be wasted by requiring the student to do unchallenging, stereotyped, and superficial experiments. "Efficient" operation in the sense of obtaining maximum data from standardized equipment should not be the goal of laboratory instruction. Rather, great effort should be expended to provide a type of laboratory instruction which will lead the student partially to discover a particular law or principle by his own efforts. This presents a challenge and allows the student to contribute to his own learning process. A law or principle arrived at in this way will not easily be forgotten and the more able student will appreciate its deeper significance. In this way the laboratory experience can contribute most forcefully to the student's assimilation of basic physical principles. It is, therefore, recommended that teachers of physics continue to give serious thought to the improvement of laboratory instruction in basic physics. In a few schools very significant results have already been achieved.

5. Textbook for General Physics

Since the educational arrangement of one teacher for each student which many consider ideal is rarely feasible, and since students cannot usually be trusted to take adequate notes on lectures, no matter how carefully delivered, the textbook will long continue to be the primary medium in the education of students, particularly in a science like physics, which demands close and repeated study.

Examination discloses that though the number of general physics texts available for students of engineering is relatively large, some of them tend to be marred by numerous shortcomings which undoubtedly lower the efficiency of the educational process. Among these are the following:

(1) There is a tendency to put too much stress on facts and too little on fundamental *ideas, principles,* and *methods.* Some textbooks pay too little attention to the methodology of physics and hence give the student little idea of the manner in which physics progresses or even of the limits of present knowledge.

(2) As a corollary to (1), some texts provide too little encouragement for the student to reason things out for himself and to test his understanding of principles and methods. There are, in general, too many problems of the simplest substitutional variety that may be used by teachers to the exclusion of the more thoughtful items.

(3) There is often too little care and imagination in the *selection* of material from the standpoint of fundamental significance and hence the books tend to be far too long and encyclopedic in character. Moreover, they appear to be growing longer. Books of 800–900 pages seem too long for the general physics course unless the assignments by the teacher are very skillfully made to eliminate certain sections.

(4) In too many cases recent developments in physics are tacked on at the end instead of being thoroughly integrated into the general development. In particular there is frequently little consideration of the fundamental role of the theory of relativity and quantum theory in the *evolution* of classical physical ideas.

(5) The mathematical methods used in texts often underestimate the intellectual capacity and interest of the student. Elementary differential and integral calculus, vector analysis, and modern mathematical concepts should be used whenever they aid in the concise rigorous formulation of principles or problems; thus the student will become accustomed to such methods and gain confidence in their use.

It is very likely that no single physics text will satisfy all teachers or any one teacher for all time. The fact that a few of the existing texts have been adopted by a large number of teachers gives evidence of the high regard with which these texts are held. Nevertheless, some members of the Committee are still seeking the "perfect" text that would be free from the objections listed above. The text for general physics that they visualize would be considerably shorter than most existing texts. It would preferably be written by a teacher who has a strong research interest, or by a group of such persons; but if by one person, he should be one who has thought a good deal about the methodology of physics and is willing to develop the subject in unconventional fashion. Such texts in special fields are now actually being written at one large institution.

6. Mathematics in General Physics Teaching

Since mathematics in the form of the calculus is the natural language of physics, it is desirable that the student should get acquainted with it early in his college career and that the general physics text should use it freely. In many institutions an introduction to the calculus is given simultaneously with general physics. In others, beginning physics is delayed so may be noted that the one-year sophomore that preliminary work in calculus may precede the first semester of physics. It is obviously very important that the physics teacher should continually stress the use of mathematics in expressing the ideas of physics. At the same time it is essential that he emphasize the physical meaning of all results obtained by mathematical analysis so that the student will not get the mistaken idea that physics is merely a collection of mathematical symbols.

The above recommendation in many instances raises problems in the teaching of elementary college mathematics. The mathematics teacher quite reasonably desires to develop in his students an *understanding* of mathematics and its meaning as a form of human activity and looks with justifiable suspicion on the teaching of mere manipulation. The physics teacher, therefore, has the responsibility to effect a gradual transition from mathematical philosophy as taught in the mathematics department to the use of mathematics as a tool as required in physics, just as the engineering teacher has the responsibility to effect a similar transition from physics as a basic science to the use of the principles of physics in solving engineering problems. To provide these transitions in a sympathetic and effective manner requires the utmost cooperation between the mathematicians, physicists, and engineers.

7. Encouragement of Experimentation

An impartial appraisal of the quality of instruction in American colleges and universities in both the sciences and engineering will reveal a distressing amount of teaching of a completely pedestrian sort. The prevalence of such mediocre efforts should not, however, conceal the fact that there are also many gifted and effective teachers and that interesting and rewarding experiments for the improvement of laboratory and classroom instruction are taking place in many institutions. It is our impression that a

wider knowledge of such experiments and innovations would encourage similar efforts and that an exchange of views would be beneficial to all concerned. Consequently, we urge that the appropriate journals of the American Institute of Physics and also the JOURNAL OF ENGINEERING EDUCATION take steps to give wider publicity to experimentation in teaching, to "case histories" of new approaches to laboratory instruction, and to similar endeavors.

The various conferences encouraged and supported in recent months by the National Science Foundation for the discussion of such topics as mechanics, thermodynamics, electrodynamics, solid state, and nuclear physics in engineering education have served a highly useful purpose by affording opportunities for the exchange of views among leaders of specialized fields. We believe that the organization of similar conferences from time to time in the future will be profitable to both engineers and physicists.

Recent meetings of the AAPT and of the Physics Division of the ASEE have had sessions devoted entirely to the teaching of general physics to engineers. We urge that meetings of this kind be continued and that whenever possible further joint meetings be held. Such meetings, by bringing together researchers and teachers, physicists, and engineers to share their experiences, their faiths and their hopes, will do much to stimulate further interest and understanding of the role of physics in engineering education.

Appendix

Summary of Information Obtained from Questionnaires

As stated previously, early this year there were sent to the physics departments of some 180 colleges, offering programs in engineering, questionnaires concerning the physics courses taken by the engineering students. To date replies have been received from about 120 colleges and the following summarizes the answers to questions on the general courses, the advanced courses, emphasis on research in classical physics, and changes in courses now being planned.

A. General Physics Course

Physics instruction to engineering students is limited to the general physics course only, in 46 per cent of the colleges. This course is required by almost all engineering schools as an integral part of the curriculum. Data derived from the questionnaires in regard to some details of the General Courses are given in the paragraphs below.

1. *The number of semester hours and the distribution of time devoted to lecture, recitation, and laboratory vary with the school.*

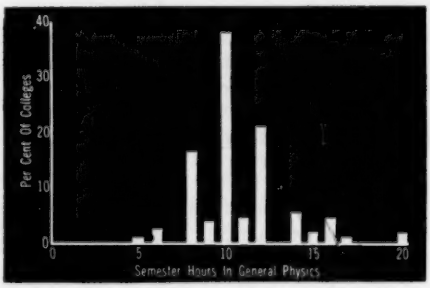

FIGURE 1

Figure 1 shows graphically the number of semester hours devoted to general physics as related to the number of colleges. It

may be noted that the one-year sophomore physics course of 10 semester hours is most popular. In many schools a two-year general course requiring up to 20 semester hours is taken by all or most engineers.

2. *Prerequisites for the general physics course for engineers.* Figure 2 shows graphically that calculus is usually required as a co-requisite for this course and that at least algebra and trigonometry are required prerequisites in almost all instances.

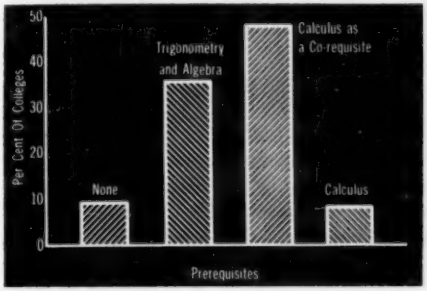

FIGURE 2

3. *Percentage of time in general physics devoted to "modern physics."* Figure 3 shows roughly the stated amounts of "modern physics" included in the general course. Although contemporary physics is concerned with fluid dynamics, thermodynamics, microwaves, and many other modern topics, the term "modern" as used here refers to atomic, nuclear, and solid-state physics. It is, of course, difficult to define just what is modern and just what is classical so that the answers can be considered only as qualitative judgments. The answers given range from very little in a few instances to more than 30 per cent at Princeton University. In most cases this treatment of modern topics is distributed throughout the course but in about one-third of the colleges it is concentrated, usually, at the end of the course.

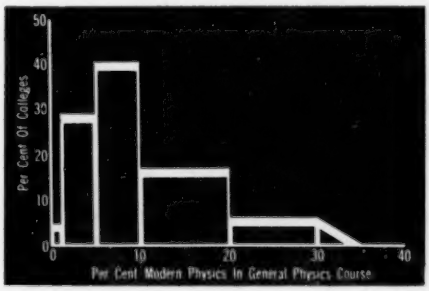

FIGURE 3

4. *Texts used in general physics.* Five texts predominate and are used by 75 per cent of the colleges. Some fifteen different texts are used by the remaining quarter of the colleges, many in only one college each.

B. Advanced Courses

In more than 50 per cent of the colleges reporting, additional physics is taken by some of the engineering students, usually as an elective. The most common additional course is one in modern or atomic physics which is taken in about 35 per cent of the colleges. As many as 325 engineering students take this course at Pennsylvania State University. The average engineering registration in advanced courses is about 30 students. Three or four different texts are popular, but a dozen others are used in one or more schools.

C. Research Interest in Classical Physics

There has been much discussion of the present-day interest of physicists in research on problems in classical physics in comparison with the widely publicized research in "modern" physics. Actually this comparison has no direct relation to the teaching effectiveness in general physics since the same critical understanding of fundamental concepts required in classical physics is basic to competent research in "modern" physics as well. Furthermore, the same point of view and attitude of mind so important to good physics teaching is present no matter in what particular branch of physics a man's research is being done. Unfortunately, there are no simple means

by which research can be reliably measured so that, although a question on this matter was included, the reader must recognize the limited reliability of such a survey. The replies indicated that 58 per cent of the colleges, all of which offer engineering education, reported research completed recently or in progress by their physics departments in mechanics, acoustics, heat or thermodynamics, electricity and magnetism, or optics. These research projects are divided as follows:

TABLE I

Field	Number of Research Projects	Number of Published Papers
Mechanics	32	24
Acoustics	23	14
Heat and Thermodynamics	30	23
Electricity and Magnetism	41	32
Optics	40	34
Totals	166	127

TABLE II

	Projects
17 colleges report research in one classical field only	17
14 colleges report research in two fields	28
15 colleges report research in three fields	45
14 colleges report research in four fields	56
4 colleges report research in five fields	20
64 Total	166

D. Changes in Physics Courses

About one-half of the physics departments specifically state that changes are being considered or planned. The most common change is the inclusion of more atomic, nuclear, and solid-state physics in the general physics course, frequently in the time provided by a reduction of engineering examples or application. About 10 per cent of the colleges are adding a course in modern physics, including atomic, nuclear, and solid-state physics, as a junior-senior elective for engineers.

OAK RIDGE INSTITUTE SECONDARY SCHOOL COURSE

The Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee, has announced a new program to assist secondary schools in science teaching. Sponsored jointly by the National Science Foundation and the United States Atomic Energy Commission, the program will enable a selected group of high-school teachers to attend a three-month course at Oak Ridge. The group will then spend nine months traveling and giving lecture-demonstrations for science classes at high schools throughout the country. The results of this experiment will be used by the NSF to plan and support future programs aimed at increasing the number of young people choosing careers in science and engineering.

The Journal of ENGINEERING EDUCATION

April, 1956 *Table of Contents* Vol 46, No 8

Article

Do You Know 608

Departments

New Members 611 In the News 617
Teaching Positions Available 615 Section Meetings 618

Report

GENERAL EDUCATION IN ENGINEERING 619

A Report of the Humanistic-Social Research Project

Preface 621 Summary 623 Introduction 626
Chapter I. The Problem of a Philosophy 632
Chapter II. The Problem of Content 640
Chapter III. The Problem of Arrangement 650
Chapter IV. The Problem of Administration 665
Chapter V. The Problem of Time 673
Appendix A: Excerpts from Field Reports 681
Appendix B: Representative H–S Sequences 696
Appendix C: Courses of Special Interest 702
Appendix D: Sample Engineering Curricula Incorporating H–S Sequences 735

Editorial Note: A preliminary report on the Humanistic-Social Research Project was given at the last Annual Meeting of the Society in June, 1955. Subsequently a draft of the final report was prepared and circulated late in 1955 to all members of the project committee. Utilizing the comments obtained from this examination, the present "Revised Report" was developed and approved by the full project committtee early in 1956. By this time, pressure was felt to print the extensive report text, and to make it immediately available both for members of the Society and for the many other persons interested in the problems of general studies.

To make possible early publication in the Journal, an unusual step was taken and the revised version was distributed in complete form to members of the ASEE General Council for approval by letter ballot. This has now been obtained, and the Report is therefore presented in this issue of the Journal *for the information of the Society*. Discussion and formal action on acceptance of the report will follow at the Council meeting in June.

The present publication is in the exact form which will be presented at the Council meeting. As for any other report, comments by the Council and any amendments or changes which may be made after discussion will be published in the Journal as soon as they are completed and released by the Committee.

Notes

Blake R. Van Leer 614 50th Anniversary Co-op. Educ. 617
ASEE Summer Schools 616 Co-op. Eduction Resolution 617

DO YOU KNOW . . . .

► . . . . That you should *Aim for Ames In '56?* Dates are June 25–29.

► . . . . That some members of ASEE are not prompt in paying their dues? Three notices have been sent to all members, but an analysis of the total membership of about 8,000 indicates that

90 members have not paid their $6.00 dues
348 members have not paid their $8.00 dues
257 members owe $16.00 in dues
151 members owe over $21.00 in dues
2 institutions have not paid their $25.00 dues
1 institution has not paid its $50.00 dues for two years
6 companies have not paid their $50.00 dues

The total value of all these dues is almost $11,500! This is a tidy sum and it will be greatly appreciated if all who are delinquent pay up promptly. The Society needs this money if it is to carry out its program as planned and budgeted. Those owing $16.00 or more are to be dropped from membership at the end of the current fiscal year, in accordance with the provisions of the Constitution of the Society. It is regrettable that such action must be taken for so large a number. But maintaining non-dues-paying members on the roster is an expensive luxury. If a man no longer wishes to be a member it is much simpler for him to resign than it is to just neglect paying dues until he is dropped. If you haven't sent in your check for the fiscal year 1955–56, please do so immediately.

► . . . . That the Council of the American Association of Physics Teachers has just voted to hold its 1957 Annual Meeting independent of the ASEE Annual Meeting at Cornell? It is regrettable that this cooperative venture failed to materialize.

► . . . . That EJC has decided the Nuclear Congress held early this year was so successful that it will be an annual event? Consideration is now being given to the detailed planning and assignment of responsibilities for the 1957 Congress.

► . . . . That at last year's Annual Meeting the General Council voted that each Section should select a liaison member for the Physics and Relations With Industry Divisions to maintain close relationship and provide direct dissemination of information of mutual interest? Up to the present time this office has received word of such selections from only two sections. More cooperation is needed if this effort is to be worth-while.

► . . . . That more than 1200 ASEE members will converge on Ames for the Annual Meeting?

If you come by car—

Ames is on trans-continental east-west U. S. Highway 30 and on north-south U. S. Highway 69.

If you come by train—

The Chicago and North Western Railroad has four trains daily from Chicago to Ames and three trains daily from Omaha to Ames. You will need to change trains at Chicago or Omaha

if you come from beyond these points. The Rock Island Railroad has three trains daily each way between Kansas City and Milwaukee, but you will have to get off at Des Moines and then take a bus for the 32 miles to Ames.

If you come by bus—

Ten buses leave downtown Des Moines for Ames daily, beginning at 7:00 A.M. The last bus leaves Des Moines at 11:40 P.M. Travel time is approximately one hour.

If you come by plane—

The nearest point for scheduled flights is Des Moines, with an airport 34 miles from Ames. United Airlines has nine flights daily from Chicago, seven from Omaha, and one from Milwaukee. Braniff has three flights daily from Kansas City, three from St. Louis, and six from Minneapolis.

Charter taxicab trips from the Des Moines airport to Ames cost about $12 for one to four persons. Rental cars are available at the airport, but it is best to make arrangements ahead of time for delivery of cars to the airport. Howard Flying Service will meet flights in Des Moines and bring one, two, or three passengers to the Ames Municipal Airport, four miles from the Iowa State College campus, for $13.20 per trip on a charter basis. Arrangements must be made by direct contact with Howard Flying Service, Ames, Iowa. The Ames Municipal Airport is also available to private planes. It has adequate facilities for servicing, and the turf runways are lighted for night landings from dusk to dawn.

► . . . . That the Humanistic-Social Summer School program, June 28–30, is based on the final report of the Humanistic-Social Research Project? At each session the teachers of courses which have proven to be successful will describe the courses they offer, discussing objectives, content, organization, reading assignments, teaching methods, and effectiveness of the courses as given. The particular courses to be discussed at each of the four sessions deal with the history of science, psychology, western civilization, and American civilization. The program will appeal especially to those engaged in teaching similar courses, to engineering educators interested in new methods of teaching the Humanistic-Social stem, and to those who may wish to incorporate such courses in their programs.

► . . . . That the Engineering Drawing Summer School is to be held at Ames on June 20–24? The theme is "Evaluation of Engineering Drawing, Descriptive Geometry, and Graphics for the Future." Particular topics to be discussed include the objectives and motivation of drawing courses, offerings which comply with the Final Report on Evaluation of Engineering Education, creative problems, and simplified drafting. Sessions will correlate and interpret what colleges are doing in terms of what is being done in industry. The program implies that the Drawing Division is taking a long look ahead.

► . . . . That the "Construction Education" summer school sponsored by the Civil Engineering Division is being held June 29 to July 1 at Ames? Conceived as a means of giving empetus and direction to the growing interest in "Construction Education"

throughout the country, the meeting will bring together representatives of education and industry. They will exchange views and experiences and develop programs of cooperation and action. The first session will present the industry point of view. This will be followed by a session discussing typical engineering curricula which prepare the student for construction work. Other topics are teaching methods used in special courses, how industry can cooperate, and, lastly, a general discussion of such topics as the needs of the construction industry for engineers, what special construction education is needed, what new developments influence tomorrow's construction, and how the construction industry can best aid and guide students and faculties.

► . . . . That at the Annual Meeting it is proposed to have available a series of exhibits on teaching aids in nuclear engineering? It is also contemplated that there will be tours through the atomic energy laboratory on the Ames campus.

► . . . . That you should Aim for Ames In '56?

► . . . . That the President of the United States for some time has been concerned as to whether our training of scientists and engineers is keeping pace with the needs of our expanding economy and national security. A special committee reported to the President that, "—we are not now training enough young people in science and engineering to meet our requirements now or in the foreseeable future. There is increasing evidence that unless substantially greater efforts are made to increase our supply of scientists and engineers, particularly those of exceptional and creative abilities, we may well face the loss of superiority in decisive areas of technology in the years immediately ahead."

The committee recognized that the Government has an important responsibility for helping to solve the technological manpower problem, but believes the solution rests primarily with leaders in education, the professions, industry, and labor. As a result, President Dwight D. Eisenhower has appointed a National Committee for the Development of Scientists and Engineers composed of representatives of sixteen organizations having a direct concern with the development of our technology.

As President of ASEE, M. M. Boring has been invited to serve on the committee. Through their meetings they plan to enlist the cooperation and support of the organizations represented for developing a coordinated action program which will help provide the highly trained scientists and engineers we need. T. H. Chilton (member of ASEE) is the EJC representative, Dr. H. L. Bevis (President of the Ohio State University) is Chairman, and E. A. Walker (Dean of Engineering at Pennsylvania State University) is Vice Chairman.

The National Science Foundation will provide staff services for the Committee and provide leadership to other departments and agencies in carrying forward activities which will contribute to a solution of the problem. R. L. Clark, formerly with the Office of Defense Mobilization, comes to NSF to serve as Executive Secretary of the Committee.

W. Leighton Collins
Secretary

NEW MEMBERS OF THE ASEE

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UIHLEIN, GEORGE VICTOR, JR., National Executive Secretary, Theta Kappa Phi Fraternity, Worcester, Massachusetts. W. R. Grogan, A. W. Back.

ULRICH, BENJAMIN HARRISON, JR., Associate Professor, Aeronautical Engineering, West Virginia University, Morgantown, West Virginia. L. Seltzer, C. H. Cather.

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WEBB, WAYNE, Professor of Physics, The Pennsylvania State University, University Park, Penn. J. A. Sauer, J. Marin.

WEINAUG, CHARLES FISHER, Professor & Chairman of Petroleum Engineering, University of Kansas, Lawrence, Kansas. J. O. Maloney, K. E. Rose.

WINOGRAD, LEE, Assistant Professor, Aeronautical Engineering, University of Maryland, College Park, Maryland. S. S. Steinberg, R. B. Allen.

YAGLE, RAYMOND ARTHUR, Assistant Professor in Engineering Mechanics, University of Michigan, Ann Arbor, Michigan. R. A. Dodge, J. S. McNown.

ZIMMERMAN, JOSEPH FRANCIS, Assistant Professor in Economics, Government, & Business, Worcester Polytechnic Institute, Worcester, Massachusetts. L. L. Atwood, A. W. Back.

ZUSPAN, G. WILLIAM, Assistant Professor, Metallurgical Engineering, Drexel Institute of Technology, Philadelphia, Penn. A. W. Grosvenor, L. P. Mains.

100 new members
381 previously added

481 new members this year

BLAKE RAGSDALE VAN LEER

President of the Georgia Institute of Technology, Blake Van Leer died January 23, 1956, in Atlanta at the age of 62. The first engineer to hold the position of President at Georgia Tech, Colonel Van Leer was appointed to the office in 1944. Under his guidance, four years later Georgia Tech obtained university status. He made possible in 1948 the establishment, as a unit of Georgia Tech, of the Southern Technical Institute at Chamblee, Georgia. A member of the ASEE since 1923, President Van Leer was a member of the General Council from 1933 to 1936, and was president of the Southeastern Section from 1939–1940.

TEACHING POSITIONS AVAILABLE

MECHANICAL ENGINEER NEEDED AS Associate Professor or Professor and Department Head. Fields of Machine Design, Air Conditioning, Heating, and Ventilation preferred. Department has recently moved into new building and is equipping new laboratories. Housing available at reduced rates. Location, South. APR-2

ASSISTANT PROFESSOR TO TEACH Civil Engineering subjects in large eastern university in metropolitan area. Good salary for right man. APR-3

ENGINEERING DRAWING, DESCRIPtive geometry teachers needed. Salary and academic rank open. Airmail to Professor L. Scott Daniel, Chairman, Department of Engineering, University of Hawaii, Honolulu 14.

ELECTRICAL, MECHANICAL, CHEMical Engineering, and also Mathematics and Physics staff openings. Industrial experience desirable. Opportunity for research. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Massachusetts.

ASSISTANT PROFESSOR—CHEMICAL Engineering for AIChE, ECPD accredited department. PhD required. To begin September 1956. Write to D. L. Green, Clarkson College of Technology, Potsdam, New York.

ASSISTANT PROFESSOR—DRAWING and Descriptive Geometry. Associate Professor to teach Machine Design, Kinematics, Drawing. Master's degree and experience required. For details write to L. M. Sahag, Head, Department of Engineering Drawing and Design, Alabama Polytechnic Institute, Auburn, Alabama.

CIVIL ENGINEERING RESEARCH AND teaching positions. Two vacancies for Assistant or Associate Professors, salaries on twelve-month basis. Part time research and part time graduate and/or undergraduate teaching. PhD preferred, MS acceptable. Candidates must have special training or experience in Highway Engineering or in Structures. Department of Civil Engineering, Alabama Polytechnic Institute, Auburn, Alabama.

EIGHTEEN ENGINEERING TEACHERS are needed in the Departments of Electrical, Mechanical, and General Engineering, The General Engineering Department supervises freshman courses in Drawing, Engineering Problems, and Mechanics. Positions are of Instructor and Assistant Professor ranks. Salaries depend upon academic background and professional experience. Men with advanced degrees are preferred. Teaching and industrial experience are desirable but not essential. Excellent opportunities for advancement. Summer engineering employment is virtually assured. Write to Dean H. E. Wessman, College of Engineering, University of Washington, Seattle 5.

ASSISTANT PROFESSOR AND INSTRUCtor at growing midwest engineering college in Department of Mechanical Engineering, effective fall semester 1956–57. Assistant Professor must have special experience or training in machine design. Teaching assignment for instructor would include: Heat-Power, Manufacturing Processes, and Laboratory. Salary in both grades dependent upon qualifications. APR-1

ASSISTANT PROFESSORS AND INstructors in Electrical and Mechanical Engineering wanted by the College of Engineering, Marquette University, Milwaukee 3, Wisconsin. Salary commensurate with qualifications. M.S. or work toward it desirable. Opportunity for part-time graduate work at state university. Please forward complete details of education, experience, and personal background to respective department chairmen.

HEADSHIP OF INDUSTRIAL ENGIneering department. Requires background of professionally responsible management position in industry or government, plus good record of publications. Research and teaching experience desirable. Age range 35–50; salary open; position to be filled before September, 1956. Write Chairman, Nominating Committee, Industrial Engineering Department, Pennsylvania State University, University Park, Pennsylvania.

ASSISTANT PROFESSORS, INSTRUCTORS, Research Assistants, and Graduate Assistants needed in Engineering Mechanics. Excellent opportunities for graduate work. Write Joseph Marin, College of Engineering, The Pennsylvania State University, University Park, Pennsylvania.

TEACHING POSITIONS IN ENGINEERING technology; teaching and industrial experience desirable. B.S. or M.S. degrees. Cooperative program—Physics, Mathematics, Engineering Drawing, Machine Design, Strength of Materials, Tool Design. Positions beginning September, 1956. Sinclair College, 117 W. Monument Ave., Dayton 2, Ohio.

ASSISTANT DEAN OF ENGINEERING, Master's degree preferred but not required. Salary to depend upon qualifications. Apply to: Dean W. A. Patterson, Fenn College, Cleveland 15, Ohio.

SIX OPENINGS IN ELECTRICAL AND Mechanical Departments. Teaching Assignments: Electric Power, Electronics, Physics, Heat Power, Engineering Drawing, other Mechanical Engineering subjects. Salary depends upon qualifications. Excellent fringe benefits. M.S. in E.E. or M.E. desired. Applicants with B.S. considered. Write to Earle M. Morecook, Chairman, Applied Science Division, Rochester Institute of Technology, Rochester 8, New York.

AGRICULTURAL ENGINEERING POSITION to teach farm structures and machinery and power courses, as well as general engineering courses. Instructor or Assistant Professor rank. Salary commensurate with qualifications. Nine month appointment. Complete new Engineering Center under construction this spring. High and dry climate, no traffic or smog, good schools, lots of elbow room, not an A-bomb target. Write Dean of Engineering, Colorado A & M College, Fort Collins, Colorado.

CHRYSLER INSTITUTE OF ENGINEERING again has openings on its full-time teaching staff. For: supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork. Desired qualifications are age 25–40; B.S. degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive. Also a teacher and supervisor of Graduate School classwork. Qualifications are age 25–40; M.S. degree in engineering; experience in teaching Mechanical Engineering subjects. Write to Chrysler Institute of Engineering, Att: L. R. Baker, Director, P. O. Box 1118, Detroit 31, Michigan.

ASEE SUMMER SCHOOLS FOR 1956

Construction Education. Sponsored by the Civil Engineering Division, June 29 to July 1, Iowa State College, Ames, Iowa. Information from Professor C. Martin Duke, University of California, Los Angeles, California.

Engineering Drawing. Sponsored by the Engineering Drawing Division, June 20–24, Iowa State College, Ames, Iowa. Information from Professor W. E. Street, Drawing Department, Agricultural and Mechanical College of Texas, College Station, Texas.

Humanistic-Social. Sponsored by the Humanistic-Social Division, June 28–30, Iowa State College, Ames, Iowa. Information from Dr. Melvin Kranzberg, Social Studies, Case Institute, Cleveland, Ohio.

IN THE NEWS

50th Anniversary of Co-operative Education

The 50th Anniversary of Co-operative Education will be celebrated by the University of Cincinnati, on April 19–25. Numerous authorities in science, business, and education will speak at three sessions on April 19 and 20, with the theme "Education and Industry at Work for Progress." Also featured will be a week-long industrial exhibit of displays by co-operative employers, the "Panorama of Industrial and Scientific Progress, 1906–1956." The Panorama will include the National Association of Manufacturers' traveling exhibit, "Americade." Details can be obtained from the 50th Co-op Anniversary Headquarters Office, 116 Baldwin Hall, Cincinnati 21, Ohio.

Cooperative Education Resolution

The Cooperative Education Division of the ASEE at its Mid-Winter Meeting, January 10, 1956, adopted the following resolution for publication in the JOURNAL:

Whereas, the cooperative plan of education which was originated in 1906 at the University of Cincinnati by the late Dean Herman Schneider has in the course of 50 years come to be adopted in one form or another by 35 or more colleges in the United States, and *whereas,* the Cooperative Education Division of the ASEE owes its existence to the pioneering efforts of Dean Herman Schneider and to the widespread recognition of the value of his ideas, and *whereas,* we wish to do honor to the originator of the plan and to the University where it had its inception.

Now therefore, be it resolved, that the Cooperative Education Division of the ASEE extend its sincere congratulations to the University of Cincinnati upon the 50th Anniversary of the Cincinnati Cooperative Plan; *resolved further,* that the members of this Division shall participate to the fullest extent possible in the observance of the Anniversary; *resolved further,* that we urge all participating firms and all colleges in our Division to be represented at the observance.

SECTION MEETINGS

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	Carnegie Institute of Technology	April 27–28, 1956	J. W. Graham, Jr., Carnegie Institute of Technology
Illinois-Indiana	Purdue University	May 12, 1956	O. W. Witzell, Purdue University
Kansas-Nebraska	University of Wichita	Oct. 26–27, 1956	J. K. Ludwickson, University of Nebraska
Michigan	Wayne University	May 5, 1956	G. H. Howell, Wayne University
Middle Atlantic	Bell Telephone Laboratories, Murray Hill, N. J.	May 12, 1956	C. C. Carr, Pratt Institute
Missouri-Arkansas	University of Arkansas	April 6, 1957	L. R. Heiple, University of Arkansas
National Capital Area	Capital Radio Engineering Institute, Wash., D. C.	Oct. 11, 1955	D. C. Jackson, Jr., Aberdeen Proving Ground
New England	Tufts University	Oct. 19–20, 1956	W. S. Evans, University of Maine
North Midwest	South Dakota State College	Oct., 1956	J. W. Howe, State University of Iowa
Ohio	Ohio State University	April 27–28, 1956	E. D. Harrison, University of Toledo
Pacific Northwest	University of Washington	May 10, 11, 12, 1956	J. B. Morrison, University of Washington
Pacific Southwest	University of Arizona	Dec. 28–29, 1956	R. G. Moses, Pasadena City College
Rocky Mountain	Denver University	April 28, 1956	W. H. Parks, University of Denver
Southeastern	Tulane University	April 5, 6, 7, 1956	D. W. Dutton, Georgia Institute of Technology
Southwest	Texas Western College	March 30–31, 1956	H. K. Bone, University of Oklahoma
Upper New York-Ontario	Syracuse University	Oct. 12–13, 1956	B. H. Norem, Syracuse University

Members of the Society are welcome at all Section Meetings

GENERAL EDUCATION IN ENGINEERING

Report of the Committee for the

HUMANISTIC-SOCIAL RESEARCH PROJECT

Editorial Note: A preliminary report on the Humanistic-Social Research Project was given at the last Annual Meeting of the Society in June, 1955. Subsequently a draft of the final report was prepared and circulated late in 1955 to all members of the project committee. Utilizing the comments obtained from this examination, the present "Revised Report" was developed and approved by the full project committtee early in 1956. By this time, pressure was felt to print the extensive report text, and to make it immediately available both for members of the Society and for the many other persons interested in the problems of general studies.

To make possible early publication in the JOURNAL, an unusual step was taken and the revised version was distributed in complete form to members of the ASEE General Council for approval by letter ballot. This has now been obtained, and the Report is therefore presented in this issue of the JOURNAL *for the information of the Society*. Discussion and formal action on acceptance of the report will follow at the Council meeting in June.

The present publication is in the exact form which will be presented at the Council meeting. As for any other report, comments by the Council and any amendments or changes which may be made after discussion will be published in the JOURNAL as soon as they are completed and released by the Committee.

Contents

Preface 621

Summary 623

Introduction 626

Chapter I. THE PROBLEM OF A PHILOSOPHY 632

Chapter II. THE PROBLEM OF CONTENT 640

Chapter III. THE PROBLEM OF ARRANGEMENT 650

Chapter IV. THE PROBLEM OF ADMINISTRATION 665

Chapter V. THE PROBLEM OF TIME 673

Appendix A: EXCERPTS FROM FIELD REPORTS 681

- General Comments
- Philosophy
- Content
- Arrangement
- Administration
- Time

Appendix B: REPRESENTATIVE HUMANISTIC-SOCIAL SEQUENCES 696

- California Institute of Technology
- Carnegie Institute of Technology
- Case Institute of Technology
- City College of New York
- Clarkson College of Technology
- The Cooper Union
- Massachusetts Institute of Technology
- Michigan State University
- North Carolina State College
- Stanford University
- University of Washington

Appendix C: Courses of Special Interest 702

History of Western Civilization	*Stanford University*
Foundations of Western Civilization	*Massachusetts Institute of Technology*
Historical Development of Western Civilization I and II	*Carnegie Institute of Technology*
The Background of Western Civilization I, II, III and IV	*Case Institute of Technology*
Contemporary Civilization	*North Carolina State College*
Humanities I and II	*Clarkson College of Technology*
Introduction to the Humanities	*Stevens Institute of Technology*
Cultural History of Western Civilization	*The Cooper Union*
Social Studies I, II and III	*City College of New York*
Economic Analysis and Contemporary Problems I and II	*Carnegie Institute of Technology*
Social-Humanities Sequence	*City College of New York*
The Background of American Democracy I and II	*Case Institute of Technology*
The U. S.: Men and Issues	*Massachusetts Institute of Technology*
Modern Western Ideas and Values	*Massachusetts Institute of Technology*
Public Affairs	*California Institute of Technology*
Contemporary Problems	*University of Cincinnati*
Contemporary Issues	*North Carolina State College*
The Uses of Language	*Rensselaer Polytechnic Institute*
Community Surveys	*Columbia University*
Applied Experimental Psychology	*Tufts University*
Biological Sciences	*Washington State College*

Appendix D: Sample Engineering Curricula Incorporating Humanistic-Social Sequences 735

Chemical Engineering	*Case Institute of Technology* *Clarkson College of Technology* *Massachusetts Institute of Technology* *Michigan State College*
Civil Engineering	*Case Institute of Technology* *Clarkson College of Technology* *Massachusetts Institute of Technology* *Michigan State College*
Electrical Engineering	*Case Institute of Technology* *Clarkson College of Technology* *Massachusetts Institute of Technology* *Michigan State College*
Mechanical Engineering	*Case Institute of Technology* *Clarkson College of Technology* *Massachusetts Institute of Technology* *Michigan State College*

Preface

THE HUMANISTIC-SOCIAL RESEARCH PROJECT has been financed by a grant from the Carnegie Corporation of New York to the American Society for Engineering Education. Grateful acknowledgment is herewith made to the Corporation, not only for its generous financial assistance but also for the continuing advice and encouragement of its staff, particularly Vice President James A. Perkins.

Initial impetus for the study came from the Humanistic-Social and the English Divisions of the Society. They are its joint sponsors and they have supplied the bulk of the manpower for the field work, though three engineers have also served as observers. The original Committee for the Humanistic-Social Research Project was appointed by Dean L. E. Grinter, then President of the Society, and was re-appointed by his successors in office, Dean N. W. Dougherty and Mr. M. M. Boring. The Committee, headed by President Edwin S. Burdell of the Cooper Union, is composed of engineering educators, administrators, and representatives from industry, as well as representatives from the humanities and social sciences. The Director of the Project has been Dr. George A. Gullette, Head of the Department of Social Studies at North Carolina State College. An Executive Committee composed of President Burdell, Dr. Gullette, Dr. Sterling Olmsted of Rensselaer Polytechnic Institute, and Dr. William C. White of Northeastern University has borne the brunt of the day-to-day decisions concerning the conduct of the investigation. An Editorial Sub-Committee consisting of Dr. Gullette, Dr. Olmsted, and Dean John W. Shirley of North Carolina State College has been responsible for drafting the report.

A tentative report, issued for limited circulation in April, 1955, has been read and criticized not only by members of the Committee and the field workers, but also by advisors from industry and from the liberal arts. Advisors from industry have included Mr. Kenneth A. Meade of the General

Motors Corporation, Mr. J. C. McKeon of Westinghouse Electric Corporation, Mr. W. F. Ryan of Stone & Webster Engineering Corporation, and Mr. T. J. Carron of the Ethyl Corporation. Advisors from the liberal arts, none of whom are directly connected with engineering education, were Dean Edward Y. Blewett, University of New Hampshire; Professor Kenneth E. Boulding, University of Michigan; Professor James M. McCrimmon, University of Illinois; Professor F. S. C. Northrop, Yale University; Professor Warner G. Rice, University of Michigan.

The Committee wishes publicly to acknowledge the generous reception its field workers were accorded at every institution they visited. They were received with a warmth that went far beyond the requirements of normal courtesy. We found a common bond of interest in the humanities and social sciences, a willingness to discuss problems candidly and frankly, and evidence of sincere and intelligent attempts to search with us for solutions to them. Immodesty compels us to add that we have received communications from a number of the institutions visited indicating that our field workers' presence on the campus provided a stimulus and encouragement which have already resulted in improvements in the teaching of the humanities and social sciences to engineering students.

Edwin S. Burdell, Chairman	The Cooper Union
George A. Gullette, Director	North Carolina State College
Maynard M. Boring	General Electric Company
Arthur B. Bronwell	Worcester Polytechnic Institute
John E. Burchard	Massachusetts Institute of Technology
Stuart W. Chapman	University of Washington
Carl W. Condit	Northwestern University
C. Rexford Davis	Rutgers University
Jess H. Davis	Stevens Institute of Technology
N. W. Dougherty	University of Tennessee
C. J. Freund	University of Detroit
T. Keith Glennan	Case Institute of Technology
Lee H. Johnson	Tulane University
Sidney D. Kirkpatrick	McGraw-Hill Publications
Sterling P. Olmsted	Rensselaer Polytechnic Institute
John W. Shirley	North Carolina State College
B. Richard Teare	Carnegie Institute of Technology
William C. White	Northeastern University

GENERAL EDUCATION IN ENGINEERING

Summary

The basic findings of this study are:

1. That engineering educators throughout the country are in nearly unanimous agreement that their students would profit—as professional men, as citizens, and as individuals—from a fuller acquaintance with the resources of the humanities and social sciences;

2. That a sizable number of these same educators are honestly fearful that attempts to incorporate into already overcrowded curricula a substantial program of humanistic-social studies may either jeopardize the quality of the technical education, or lead to superficiality in the treatment of the humanities and social sciences; but

3. That some thirty or more of our leading engineering schools have demonstrated such fears to be groundless by developing carefully planned programs that provide a sound introduction to the humanities and social sciences while simultaneously reinforcing the student's engineering training.

In view of these findings, our report confines itself chiefly to the practical problems that confront those who must plan, initiate, and maintain significant humanistic-social programs for engineering students. The Appendices to the report contain detailed information about the content and operation of representative existing programs. The body of the report contains discussions—and where appropriate, recommendations—concerning the problems most frequently raised by those interviewed by our field workers.

This investigation has made the Committee acutely conscious of wide variations in facilities, aims, and potentialities among engineering schools, and its most fundamental recommendation is that each institution take the steps necessary to hammer out for itself a feasible program appropriate to its own needs. No standardized pattern is, at least at present, available for mass distribution. Certain observations and recommendations, however, appear to have some general validity, and these may be summarized as follows.

Humanistic-social programs for engineering students are most successful when these conditions prevail:

1. There is vigorous administrative support for the program;
2. There is full cooperation and understanding between the engineering and liberal arts faculties;
3. The studies in the humanities and social sciences are treated as an integral part of the student's scientific and technical education;
4. Experimentation with fresh materials and methods is encouraged;
5. Advantage is taken of the increasing maturity of the student in his upperclass years.

Recommendations

Philosophy

1. The formulation of objectives must be carried out jointly by the engineering and arts faculties.
2. The humanities and social sciences must be understood as professional disciplines in their own right.
3. Engineering must be viewed as a profession with social responsibilities.

Content

1. Humanistic-social studies must be distinguished from business training.
2. A humanistic-social program must be humane as well as social.
3. Experimentation should be encouraged in:
   (*a*) Establishing functional relationships between the work in composition and speech, and the work in technical courses as well as in humanistic-social courses;
   (*b*) Capitalizing on the student's knowledge and interest in his professional fields by using materials from the history and philosophy of science and the history of technology;
   (*c*) Capitalizing on the student's interest in music and the graphic arts.

Arrangement

1. We reaffirm the recommendation of the Hammond Report for a "designed sequence of courses extending throughout the four undergraduate years."
2. Courses should be arranged to facilitate emphasis on the interrelationships that exist among the fields of knowledge.
3. Elective work must be carefully controlled to assure that it serves the purposes of the planned sequence.
4. The Engineering school should, where possible, join forces with other professional or semi-professional schools in establishing a common general education program for their students.

Administration

1. Presidents, Deans, and other key administrative officials must take the initiative in pushing for a planned program.
2. Both the engineering and the arts faculties must be brought in at the planning stage.
3. A permanent committee must be established to encourage, review, and reappraise all aspects of the work as it goes forward.
4. Special steps must be taken to assure the professional advancement of faculty members who devote a major share of their time to the humanistic-social program.

Time

1. We reaffirm the recommendation of the Hammond Report that the humanities and social sciences be given "a minimum of approximately 20% of the student's educational time. This allotment should be at least the equivalent to one three-hour course extending throughout the curriculum, and on the average somewhat more."
2. Time may be saved by exploiting both the vertical sequence and the interdisciplinary approach to subject matter.
3. Time may be saved by more careful integration of the scientific and technical work.
4. ROTC credit should not be substituted for work in either the humanistic-social or the scientific-technical stems.

Introduction

THE HUMANISTIC-SOCIAL RESEARCH PROJECT is the latest in a series of self-evaluations sponsored by the American Society for Engineering Education during the past fifty years. It is in one sense a by-product of the work of the Committee on Evaluation of Engineering Education headed by Dean L. E. Grinter of the University of Florida. In another sense it is a continuation of the work of the 1944 Committee on Engineering Education After the War, which reaffirmed the recommendations of the 1940 Committee on the Aims and Scope of Engineering Education. Both of these committees in turn drew heavily on the findings of a long series of studies conducted during the twenties and thirties and gathered together as the Report of the Investigation of Engineering Education. The current project was organized in 1954, exactly a decade after the publication of the Report of the Committee on Engineering Education After the War (popularly called the Hammond Report). Its purpose has been two-fold: (1) to consolidate and make available the experience of engineering schools during the past ten years in developing workable programs of study in the humanities and social sciences; (2) to make recommendations looking to the future strengthening of this portion of engineering education.

It early became clear that the kind of information the committee sought could not be satisfactorily obtained through questionnaire techniques, nor through the perusal of college catalogues. Instead, plans were laid to send carefully chosen volunteer observers to as many institutions as possible, in order that they might gain firsthand knowledge of various humanistic-social programs in action, and have an opportunity to discuss their operation with those responsibly concerned. These field workers met and agreed upon procedures at a two-day post-session following the annual meeting of the Society in 1954. Workers have since visited, usually in teams of two for a two day period, approximately sixty engineering schools. Detailed reports on these visits have been filed and they, together with up-to-date information supplied in writing by those institutions that could not be visited in person, constitute the basic data on which our report rests.

Each of the field reports consisted of three sections: (1) a factual section containing an objective description of the existing humanistic-social program,

its origin, development, and administration. Wherever possible, this section has been checked for accuracy with officials of the institution visited. (2) A documentary section which included committee reports, course syllabi, reading lists, examination questions and other materials that shed light on the actual working of the program. (3) A commentary section in which the field workers made a frank appraisal of the program and its operation. In order to encourage candor, workers were assured that the commentary section would be held in confidence. The other sections, however, are open for perusal, in the office of the Director, by anyone who may have a legitimate interest in them.

The kind of research here undertaken is not readily reducible to tabular form. We have been concerned with various methods of incorporating the humanities and social sciences into engineering curricula, with the formulation of objectives, with definitions of what constitutes the humanities and social sciences, with motivation, with staff problems, and with a score of similar considerations. We have, in short, been concerned with ideas, and with attempts to determine which ideas seem to work well and which do not. Obviously there are no objectively verifiable standards by which such matters may be determined. We have had to rely upon the professional judgment of engineering educators, over a thousand of whom have been interviewed. Their best thinking, as reported by competent observers, provides the basis for the discussions and recommendations in this report.[1]

We have tried to keep our attention focussed on the crucial problem of how to develop and maintain an effective program of humanities and social sciences in the very limited time usually available in an undergraduate engineering curriculum. There are many intimately related issues involving, for example, high school preparation on the one hand, and graduate study on the other, but we have felt we could perform the greatest service by resisting the temptation to touch on all facets of the problem, and giving our full attention to collegiate curricula.

Our task has been complicated by the fact that engineering schools throughout the country are at widely different stages of development in their thinking and in their practice regarding humanistic-social studies. No two institutions that we know of have identical programs. No two have responded to the Hammond Report in the same way. We have attempted to study carefully the experience of institutions that have developed what appear to be successful humanistic-social programs, in the belief that a report of their experience can be of great use to other institutions. We have also, whenever possible, visited schools where the accomplishment appears to have

[1] For those interested in a statistical study, we call attention to the 1954 Pamphlet No. 114 of the U. S. Department of Health, Education, and Welfare: *General and Liberal Education Content of Professional Curricula: Engineering*, by Jennings B. Saunders, Office of Education.

been slight, and we have done so in the belief that a sympathetic understanding of the practical problems involved is indispensable if we are to make realistic suggestions.

It should be said that in using a sampling method we are aware that we have missed some institutions where major progress has been made. Our inability to visit an institution implied no judgment whatever on the merits of its program. Nor will we in the course of this report refer to institutions by name, except in the Appendix where selected sequences and courses are described without comment. This is not because we hesitate to give credit where credit is due, but because we are extremely conscious of the individual nature of each institution's problems, and we do not want to encourage unfair comparisons. Our essential concern in this report is with ideas, and we think attention can best be focussed on them if the institutions and the individuals involved remain anonymous.

Instead of cluttering the text of the report with footnotes and quotations from the field reports, these have been included in a separate section of the Appendix. It is our hope that this separation of the discussion of ideas from the factual and critical data will make the report not only more readable, but more practically useful to administrators, faculty members, and committees who are dealing with these problems at the local level.

We have not included a bibliography, since the staff of the Cooper Union Library has recently completed a revised and comprehensive edition of *The Humanistic-Social Stem in Engineering Education,* a bibliography covering items from 1876 through May, 1955. One complimentary copy of this volume is available to each ASEE member upon application to Joseph N. Whitten, Librarian, The Cooper Union, Cooper Square, New York. Others may purchase copies at a price of 50¢ each.

This report represents, of course, the work of many hands, and the views expressed are those of no single individual. If allowances are made for the human frailty of editors, these views may be taken as a composite of the best thought of some forty educators and engineers who had before them factual information from nearly 130 engineering schools and a distillation of opinion from over a thousand interviews.

Field Workers

Bartlett, Howard R., Massachusetts Institute of Technology
Brown, C. A., General Motors Institute
Brown, Wentworth K., Rensselaer Polytechnic Institute
Burdell, Edwin S., The Cooper Union
Chapman, Stuart W., University of Washington
Christensen, Glenn J., Lehigh University
Farrell, Thomas, Jr., State University of Iowa
Fatout, Paul, Purdue University
Gullette, George A., North Carolina State College
Harman, Willis W., Stanford University
Hobgood, Alton A., Georgia Institute of Technology
Kranzberg, Melvin, Case Institute of Technology
Laity, Clifford, Montana School of Mines
Lambert, John R., Jr., North Carolina State College
Lawrence, A. A., U. S. Coast Guard Academy
Lee, John F., North Carolina State College
Lowenthal, David, Ford Faculty Fellow, Harvard University
McKean, Keith, Ford Faculty Fellow, Yale University
Mueller, Ronald H., Rensselaer Polytechnic Institute
Olmsted, Sterling, Rensselaer Polytechnic Institute
Pitman, James H., Newark College of Engineering
Shirley, John W., North Carolina State College
Shurter, Robert L., Case Institute of Technology
Stillman, Donald G., Clarkson College of Technology
Syverson, Aldrich, Ohio State University
Weeks, Robert P., University of Michigan
White, William C., Northeastern University

Institutions Visited

University of Alabama
Alfred University
California Institute of Technology
University of California—Berkeley
University of California—Los Angeles
University of Southern California
Carnegie Institute of Technology
Case Institute of Technology
University of Cincinnati
City College of New York
Clarkson College of Technology
U. S. Coast Guard Academy
Colorado School of Mines
University of Colorado
Columbia University
The Cooper Union
Cornell University
General Motors Institute
Georgia Institute of Technology
Illinois Institute of Technology
State University of Iowa
Johns Hopkins University
Lafayette College
Lehigh University
Louisiana State University
University of Massachusetts
Massachusetts Institute of Technology
Michigan State College
University of Minnesota
Missouri School of Mines
Montana School of Mines
University of New Hampshire
New York University
North Carolina State College
Northeastern University
Northwestern University
University of Notre Dame
Ohio State University
University of Pittsburgh
Princeton University
Purdue University
Rensselaer Polytechnic Institute
Rice Institute
South Dakota School of Mines
Stanford University
Stevens Institute of Technology
University of Tennessee
Tufts College
Tulane University
University of Utah
Virginia Polytechnic Institute
University of Virginia
State College of Washington
University of Washington
Washington University
Wayne University
University of Wisconsin
Yale University

Institutions Replying to Questionnaire

University of Akron
Alabama Polytechnic Institute
University of Arkansas
Bradley University
Polytechnic Institute of Brooklyn
Brown University
Bucknell University
The Catholic University of America
The Citadel
Clemson College
Dartmouth College
University of Dayton
University of Delaware
University of Denver
University of Detroit
Drexel Institute of Technology
Duke University
École Polytechnique (Montreal)
Fenn College
University of Florida
George Washington University
University of Houston
University of Idaho
University of Illinois
Iowa State College
Kansas State College
University of Kansas
University of Kentucky
Louisiana Polytechnic Institute
Lowell Technological Institute
University of Maine
Manhattan College
University of Maryland
University of Michigan
University of Mississippi
University of Missouri
Montana State College
University of Nebraska
Newark College of Engineering
New Mexico College of A & M Arts
North Dakota State College
University of North Dakota
Norwich University
Oregon State College
Pennsylvania State University
University of Pennsylvania
Pratt Institute
University of Rhode Island
University of Rochester
Rose Polytechnic Institute
Rutgers University
University of South Carolina
South Dakota State College
Southern Methodist University
Swarthmore College
The A & M College of Texas
Texas Technological College
The University of Texas
University of Toledo
University of Tulsa
Union College
United States Naval Academy
U. S. Naval Postgraduate School
Utah State Agricultural College
Vanderbilt University
University of Vermont
Villanova University
Virginia Military Institute
Webb Institute of Naval Architecture
West Virginia University
Worcester Polytechnic Institute
University of Wyoming

". . . the formulation of objectives must be carried out jointly by the engineering and arts faculties."

The Problem of a Philosophy

THE most abstract and theoretical of the problems confronting the humanities and social sciences in engineering education is also the most practical. This is the problem of defining objectives, of specifying a philosophy upon which programs may be built. Administrative arrangements, course content, staff effectiveness, adequate curricular time and the most efficient use of that time, all are directly dependent on the existence of a carefully thought out philosophy of general education that is suitable to the needs and possibilities of particular institutions. The conflicts and misunderstandings which bedevil many campuses depend ultimately for their resolution on the working out of an educational philosophy that is mutually acceptable to the engineering and the liberal arts faculties, and to which both can give their wholehearted support.

The committee did not, in fact, anticipate the confusion over objectives which it found to exist on so many campuses. More than ten years ago the Hammond Report came to grips with this problem, and made recommendations which were approved by the Society. The goals of what that report called the humanistic-social stem were stated, not in terms of subject matter, but in terms of competences it was believed the humanities and social sciences could help the students acquire:

1. An understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development.
2. The ability to recognize and make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends.
3. The ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English.
4. An acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence on civilization.
5. The development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career con-

sistent with the public welfare, and to a sound professional attitude.

6. The attainment of an interest and pleasure in these pursuits and thus of an inspiration to continued study.

Our study indicates that while many institutions have found this statement of objectives practical and suggestive, almost none have been able to adopt it without modification for their own programs. Instead, the usual procedure has been for a committee, or a series of committees, to hammer out a set of principles that would take into account local conditions and local needs. In view of this fact, the present report will not attempt to formulate a supplementary or competing statement of objectives, but will reaffirm, in principle, the overall objectives for the humanistic-social stem as stated in the Hammond Report. In addition, it will report on certain conclusions it seems fair to draw from its observations of the way in which successful programs of study have been initiated in the various institutions visited.

II

THE first of these conclusions is that the formulation of objectives must be carried out jointly by the engineering and arts faculties. Neither group, acting independently, is likely to define the task in a way that will win the prompt and understanding approval of the other, and our field reports are unanimous in pointing out that such mutual approval is indispensable to a successful program. We believe that the lack of a jointly formulated philosophy is the basic cause of the misunderstanding and inefficiency that was found on many campuses.

In specifying what is meant by "misunderstanding and inefficiency," we are compelled to report that the ancient war between the engineering and the arts faculties still continues in a good many institutions, particularly the larger state universities, where the two faculties are frequently separated physically as well as spiritually. The arts faculty at such institutions still cherishes a belief that the engineer is a rough, uncouth fellow wearing boots and an open flannel shirt. His intellectual equipment consists of a transit and a slide rule. He has no manners, and he wants none. He pushes jobs through by beating up his men with his bare fists. His acquaintance with the arts is limited to cheap movies, and his acquaintance with literature to comic books. He is crass, materialistic, insensitive. And it must be admitted that this picture appears to have considerable appeal for a certain type of engineer, who does nothing, in consequence, to destroy it.

At the same institutions, the engineering faculty will give evidence that it regards the typical arts man as a pale, ascetic dreamer, forever in need of a haircut. He is devoted to modern art, modern music, modern literature, and he talks incomprehensibly about all three. He is addicted to books, and

knows nothing whatever about science or mathematics. He is a thoroughly impractical fellow, probably a little pinkish politically, who gets by only because he has the gift of gab. And it must be admitted that this picture appears to have considerable appeal for a certain type of arts man, who does nothing, in consequence, to destroy it.

On the other hand, we have evidence that conflict disappears almost completely on those campuses where the arts and engineering faculties are thrown together as colleagues on an equal footing, and where there are systematic procedures for bringing the two groups together to work out their mutual problems. "To know him is to loathe him," says one character of another in the play *Stalag 17*. The committee is glad to report that this pleasant perversion of an ancient bit of wisdom does not apply to the engineer and his counterpart in the arts school. Mutual understanding breeds mutual respect. Yet the committee does not wish to sound too much like Pollyanna. Even under ideal conditions there will be warm clashes of temperament and interest, but the clashes cease to be drawn on inter-school lines. Character assassination becomes happily indiscriminate, as it should be in any well-regulated academic community!

The war between the faculties might be condoned as an example of good clean mayhem were it not for the fact that innocent bystanders too often become the chief victims. The sober truth is that the attitudes of the engineering faculty communicate themselves to engineering students. At institutions where the faculty exhibited the greatest belligerence about their colleagues in the arts faculty, we invariably found the greatest number of student complaints about the humanistic-social work. At institutions where the engineering faculty displayed a sympathetic understanding of the humanities and social sciences, student resistance to the program was at a minimum.

This whole matter of atmosphere, difficult though it may be to pin down, is of central importance in education. Though not strictly a part of a philosophy of education, it appears to be closely related, since atmosphere reflects the philosophy under which the institution operates. Perhaps it is not too far-fetched to say that the college environment conditions the future intellectual development of the young man in the same way that the home environment conditioned his emotional development as a child. In both instances, the basic attitudes of those around him are communicated indirectly, by subtle signs and clues dropped in the course of conducting quite ordinary affairs. If the engineering faculty are to hope for a maximum return from the time invested in a humanistic-social program, they must help provide a climate of opinion congenial to all serious intellectual inquiry. And the arts faculty, on its part, must display an understanding of and respect for the rigorous discipline involved in scientific and technical education. Neither of these necessary attitudes can be successfully faked, and this is but a further reason for our insisting that the point of departure for any genuinely useful col-

laboration between the two faculties must be the establishment of systematic means of communication. Only thus can a workable philosophy be achieved and permitted to flourish.

III

THE second conclusion to be drawn from our observation of how programs were initiated and planned consists of a series of warnings. We think there are at least three obvious dangers against which all planners should be on guard. They are:

A. The danger of defining the function of the humanities and social sciences too narrowly.
B. The danger of defining their function too superficially.
C. The danger of defining their function too ambitiously.

Because the humanities and social sciences *do* contribute to the professional competence of the engineer, there is a tendency in some schools to limit their function to the improvement of technical efficiency, or at least to justify them on narrowly utilitarian grounds. It is argued that an engineer should be able to write well and speak effectively, that he should be able to win friends and influence people, that he should understand business problems and operations. Therefore he should take courses in composition, technical writing, speech, applied psychology, and business administration. On the same basis some schools have attempted to justify the traditionally humane disciplines of literature and philosophy as subjects which will enable the engineer to manage people more effectively as a result of an improved ability to analyze their motives and points of view. It is easy to understand why arts faculties have sometimes fallen prey to this rationalization. By using these tactics some have probably achieved a hearing for courses which would otherwise have been neglected.

The committee believes that the humanities and social sciences are, in a deeply serious sense, practical and useful. It believes that engineering educators have performed an invaluable service to liberal education by their stubborn insistence that contemporary relevance is the standard by which to judge any humanistic-social program. What we object to is an essentially frivolous definition of practicality that limits its attention to the development of a few surface skills, while failing to recognize that literature and philosophy and social organization are, like science itself, basic aspects of human activity in which depth of understanding provides the only sound foundation for the student's further growth. The emphasis upon immediately useful techniques narrows the scope of the humanities and social sciences and seriously diminishes their educational value. No small part of the job of any teacher in the humanities and social sciences is to develop in his students some appre-

ciation of the nature and the value of the disciplines they represent. If he himself either conceives them, or has allowed himself to be trapped into rationalizing them, in an essentially false and narrow way, it is difficult to see how he can persuade his students of their genuine worth.

Perhaps even less defensible is the view which regards the humanities and social sciences as a cultural veneer designed to make the engineer acceptable in polite society. This finishing school concept of general education not only fails to justify the inclusion of liberal arts courses in an engineering curriculum; it makes them look positively ridiculous. From this standpoint, literature and the arts are primarily conversation pieces, or aids to smoother family and social relations since they give the engineer something to talk about besides transistors, strain computations, and fluid flow. Carried to extremes, this attitude leads to the expectation expressed on one campus that the humanities and social sciences should inculcate good manners and teach students not to walk four abreast on campus walks, nor to attend classes without neckties. The comment which has already been made about the narrowly utilitarian point of view applies with even greater force to the superficial one. A statement of objectives which fails to respect the centuries of solid scholarly accomplishment represented by the humanities and social sciences can scarcely provide the requisite intellectual framework for a sound program of study.

On the other hand, an overstatement of what may reasonably be expected from the humanities and social sciences, while proceeding from entirely different motives, may be equally dangerous. Implied in some of the glowing statements the committee has examined is a faith that a few courses in the humanities and social sciences can provide health and emotional adjustment, personal and social success, clarity of thought, moral integrity, civic responsibility, aesthetic sensitivity, professional vision, and in general a kind of serenity and wisdom we had thought was reserved for Providence alone. The objectives which some schools profess to accomplish in courses involving twenty-one to twenty-four semester hours would appear to rival, or even to outstrip, what might be expected from a full four-year liberal arts program. The committee doubts that grandiose statements of good intention serve any very useful educational purpose. On the contrary, they are likely to lead either into self-deception, or into frustration and disillusionment.

IV

THE third conclusion the committee draws about the formulation of an adequate philosophy is that it must be based upon a broad view of the potentially professional character of engineering, as well as on a responsible view of the values that are inherent in the humanities and social sciences. In the education of the professional engineer, the function of the humanities

and social sciences should not be limited to the improvement of communication skills and the development of amiable employees. The engineer is a responsible professional man, whose every professional act has human and social consequences. Whether he is aware of it or not, he is instrumental in the creation of a new society and a new economic order, as well as a new physical environment. One result of his professional accomplishments is that he is being called upon to accept an increasingly responsible role as a leader in his community.

To meet his growing responsibilities and to realize his capacities as a human being, the engineer needs both professional competence and a broad understanding of himself and of the world in which he lives. He needs depth, flexibility, and a capacity for growth in directions which we ourselves can today only dimly visualize. Like other professional men, he does not graduate from college with a completed education. The job of engineering education is to provide him with a foundation upon which he may build a career of genuinely professional stature.

Given this view of the engineer as a professional man and as a human being, the humanities and social sciences can take their place as an integral part of his total education. They do not stand apart from the rest of the curriculum. They support the scientific-technical training, and are in turn supported by it. They contribute to professional competence not merely in the narrowly vocational sense but in the broad sense of enabling the engineer to see his own activities in their human and social contexts, to understand his own objectives, methods, and problems in relation to the objectives, methods, and problems of men engaged in other activities.

But the humanities and social sciences have a function to perform which goes beyond even this broad concept of professional development. For the engineer, as for all men, they represent the heart of our inherited human experience. The humanities—whether they are thought of as specific disciplines (literature, music, art, philosophy, and history), or as a record of man's intellectual, cultural, and emotional development—are concerned primarily with individual awareness, the knowledge of self, of the condition of man and of the quality of human experience. The social sciences, considered either as specific disciplines (economics, history, political science, sociology, anthropology, and sometimes psychology), or as a record of social and political development, are concerned primarily with man's relations with his fellows.

If the social sciences are not quite sciences, they still stand with the natural sciences as continuing evidence of man's stubborn determination to exert control over his own destiny through reason and understanding rather than force. And it should be particularly rewarding for the engineering student, trained as he is in the physical sciences to respect exact quantitative measurement, to confront some of the complexities that arise when it is human

rather than atomic behavior that is being studied. This point need not be labored, however, since the committee found that, in general, engineering faculties were favorably disposed toward studies in the social sciences, particularly economics. What was not so apparent was a similarly high regard for work in literature, philosophy, and the fine arts.

The committee believes that any philosophy of general education that fails to take account of the function of the humanities is wholly inadequate. The humanities are uniquely concerned with ends rather than means, with goals rather than methods. In religion and art, in literature and philosophy, the student is compelled to confront the big and ultimate human problems: What are we doing here? Where are we going? What is the good life? What is man that anyone is mindful of him? No profession and no individual can hope to achieve a sense of purposeful direction while ignoring these questions, nor while ignoring the great monuments to the human spirit that have been achieved as men have sought answers to them. The committee believes that a sound humanistic-social program for engineering students must be humane as well as social.

V

WHAT has been said so far has been, as we indicated it must be, fairly theoretical and abstract, yet it reflects one of the fundamental findings of our total study, namely, that where we found inadequate programs, confusion, indifference, and even hostility, the difficulties seemed always to stem from the fact that responsible members of the faculties involved had never threshed out together a mutually acceptable understanding of what the humanistic-social program was expected to accomplish. It should perhaps be added that institutions that have worked out a basic philosophy and a reasonably specific statement of objectives have found both to be strangely impermanent. As programs have grown and experience has increased, both the philosophy and the specific objectives have changed. This we believe to be not only inevitable, but a sign of genuine educational development. The committee would not want to be understood as subscribing to the view that a theoretical statement of principle, arrived at in advance of the practical applications, will automatically cure all educational ills. This would be patently unrealistic, for, as one of the critics of our Tentative Report argues, "We are studying here not a static process but an essentially dynamic and continuing process in which the objectives are continually modified as they are compared with experience, as well as providing a criterion by which experience itself is judged and modified."

The committee urges only that this dynamic process is imperative for a successful humanistic-social program, and that it must get started in joint dis-

cussions between the engineering and the arts faculties. We have also warned of certain pitfalls which such discussions ought to avoid, the pitfalls of a too narrow, a too superficial, or a too unrealistic definition of the task assigned to the humanistic-social stem. Finally, we have suggested that as preconditions to the shaping of a philosophy and the specification of objectives, there must exist a long-range view of the future of the engineering profession, and an understanding of the great reservoirs of human experience which the humane and social disciplines can offer to engineering students.

"The proliferation of content in all fields, while a remarkable human achievement in itself, is also one of the most frightening aspects of our disturbing age."

The Problem of Content

If this report is to be as practically useful as it hopes to be, something must be said about the subject matter which a sound program in the humanities and social sciences should contain. The committee is quite aware of the hornet's nest it may here be stirring up. Any liberal arts man worth his salt believes that what he teaches is the most important thing in the world. He has, after all, chosen to devote his life to it and ordinarily has done so after careful deliberation. It will surprise no one, therefore, to learn that historians tend to feel that more attention should be paid to history, philosophers argue for more philosophy, and political scientists are convinced that what is needed is more study of political science. Yet it is transparent that the range of possible courses is so vast, and the time available so short, that no engineering student can possibly take all the work that is thought by one or another of the representatives of the liberal arts to be of supreme importance. Some choices must be made.

The committee is conscious that many harried administrators throughout the country would welcome a firm and specific decision as to what those choices should be, but such a decision is clearly outside our province. Moreover, we would not, if we could, attempt to dictate in detail the subject matter content for any program, for the traditions, the facilities, and the relative academic strength of the several disciplines vary enormously from institution to institution. We can, however, reiterate certain principles that have already been mentioned in connection with objectives, and then discuss some developments within the subject matter fields that seem to us important enough to be brought to the attention of local committees which will have to make decisions about content. We also call attention to Appendix B of this report, which contains representative samples of humanistic-social programs now in actual operation in various types of institution.

II

One principle to be followed in determining content was enunciated over ten years ago in the Hammond Report: "Discriminate between humanistic studies and business training." The present committee has already reiterated

that warning, not because it holds any brief against courses in accounting, business law, patent law, business administration, personnel management, etc., but because it believes that the broad objectives that have been established for the humanistic-social program are not likely to be achieved through the addition of courses that are semi-professional in intent and emphasis. It may be pointed out that an increasing number of engineering schools are making available to their students options that combine engineering and business training and these seem to the committee to be meeting a very real need. The sole point we make is that business training must not be confused with humane and social studies that serve quite different educational purposes.

Another principle is that some reasonably equal balance must be sought between work in the humanities and work in the social sciences. Both are important, but they are not identical and we have already noted a tendency on the part of engineering schools to weight their programs unevenly in favor of the social sciences. In the long run we believe this will prove to be a mistake, and we recommend that planners make a conscious attempt to provide something like equal experience in both areas for all students.

III

One of the most interesting, though perplexing, parts of our investigation was the attempt to discover what changes, if any, in content and approach are observable within individual courses when these courses seek to achieve the objectives of the Hammond Report. It is perfectly obvious that when engineering educators agree that their students should have more acquaintance with literature, philosophy, history, economics, and the other humanities and social sciences, they have scarcely scratched the surface of the problem of content. What kind of literature, and taught with what emphasis, toward what ends, and by what means? What kind of history: American? European? Oriental? Ancient or modern? Cultural or political? Questions like these are not readily answerable, particularly in the midst of a period of educational change and experimentation like the present one.

There is something ironical in the fact that engineering educators have turned for additional assistance to their colleagues in the liberal arts at the very time that the liberal arts themselves are undergoing a critical re-examination, particularly with respect to their function in general education. This is a time of ferment for the humanities and social sciences, and the committee's job is not made easier by that fact. The discussions which follow are, however, an attempt to make easier the job of those who must make the practical decisions in curriculum planning. Touching as they must upon many hotly debated educational issues, the discussions themselves will be open to criticism (as has been amply evidenced by comments on the tentative version of this report). The committee believes that it must take that risk,

but would like to make clear that it is not pretending to make an exhaustive analysis of all aspects of the general education problem. It seeks only to call attention to certain developments that it thinks are of special interest to engineering educators.

1. The first objective listed in the Hammond Report was the achievement of *"an understanding of the evolution of the social organization within which we live and of the influence of science and engineering on its development."* This clearly calls for a consideration of the place of history in the curriculum. As we have already indicated, history is of many varieties. The commonest courses taken by engineering students are American History, World History, and Modern European History, the last mentioned usually beginning with the Renaissance and dealing with American developments from the eighteenth century on. Several states require a course in American History of all students in state-supported institutions, or at least have a state requirement which a course in American History will satisfy. On the other hand, we found a few institutions that prohibit the use of American History as a means of meeting the humanistic-social requirements, not because of any objection to the content, but because so many students have had a considerable amount of American History in high school that it is felt they particularly need the enlarged view which it is hoped World or European History will provide.

The content of world history courses would make an interesting study in itself, for they exhibit in miniature the same pressures, and require the same hard decisions, that the whole humanistic-social program does. The subject matter of world history, after all, is everything that has happened in the world up to the present moment. Obviously, considerable selection is necessary. Yet, before mentioning some of the principles of selection, it should be pointed out that two expansionist tendencies were noted. Many historians have felt that the traditional western civilization course is too narrowly provincial and does not prepare students for an understanding of the Orient, or of the new powers that are bound to be forced upon their attention by the march of events in the decades ahead. A second expansionist tendency has been to push back into pre-history in order to take advantage of the accumulating body of anthropological data, and to give students some sense of the enormous time span involved in man's struggle to establish himself on the earth—a span in which the four or five millenia of recorded history become relatively insignificant.

Confronted with the clearly impossible task of surveying the whole domain of world history, a growing number of institutions have adopted what is rather inelegantly called the "block and gap" or the "posthole" approach. This means that the attempt to cover in chronological order even a highly selected portion of the material is abandoned, and instead certain crucial periods in history, selected because they are thought to have particular relevance to our own time, are studied intensively. Thus a student may start

with Athens in the fifth century, B.C., jump to Europe in the thirteenth century, A.D., move to sixteenth century England, eighteenth century France, and end up with twentieth century America. Two of our leading engineering schools have developed two-year courses on this plan, and have exploited its potentialities beyond anything we know of in similar courses for liberal arts students.

Another development in the teaching of history to engineering students deserves special mention. A fairly sizable number of institutions are beginning to pay considerable attention to the history of science and the history of technology or engineering. Sometimes separate courses are offered, sometimes the material is incorporated in a world or European civilization course.

Our field workers report, and both they and our advisors display, a difference of opinion as to the value of this development. There are those who feel that it marks an unjustified adaptation of course materials to the supposed needs and interests of a special group of students, and must lead inevitably to a distortion of historical perspective. The place of science and technology in the development of civilization should not, of course, be ignored, but to single them out for special attention is not only historically unsound but may defeat the major purpose of a history course, which is to demonstrate the interconnections and interrelationships that exist among the various forces that shape any society. Also, this view is apparently influenced by the belief that the humanities and social sciences should provide engineering students with an experience as distinct as possible from their technical work, and this can scarcely be done if science and engineering remain the focus of attention.

On the other hand, there are those who see in this development not only a pedagogical device useful in interesting engineering students in historical studies, but a needed corrective to our habitual historical perspective. Science and technology have been too long neglected as fundamental determinants of our whole way of life. According to this view, the first systematic history, as it developed in the eighteenth and nineteenth centuries, was essentially political largely because those for whom it was intended were public officials, or persons preparing themselves for participation in public affairs—an example would be the British universities preparing young men for various administrative posts throughout the empire. After Spencer and Marx, in the middle of the nineteenth century, attention was more and more focussed on the social and more particularly on the economic forces in history, and this emphasis exactly corresponded with the growing importance of the business man in western society. Now, it is pointed out, the scientist and the engineer are becoming the dominant figures in our society, and history is again shifting its attention, this time toward science and technology.

This clash of views is not of the sort that this committee can, or perhaps should, attempt to resolve. The Hammond Report calls for some attention to

"the influence of science and engineering" on the development of our social organization, and our study indicates that such attention is frequently given. Our reports indicate further that student response to this emphasis is good. The committee feels justified in concluding that here is a development of special interest and importance for engineering education, that it is a development which should be encouraged, but that there are possible dangers of overemphasis and distortion that must be guarded against.

2. The second specific objective proposed by the Hammond Report is concerned with several of the social sciences. It calls for *"the ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose towards these ends."*

At least one course in economics is a standard requirement in almost all engineering curricula, apparently because it is thought of as the most practical of the social sciences and also because it is commonly prerequisite to later courses in management and business administration that are taken by large numbers of engineering students. So far as content is concerned, the movement in the last two decades, if we interpret it correctly, has been away from a purely institutional approach and toward a national income approach with more emphasis given to distribution, methods of growth, and an analysis of the functions of any economic system. From the point of view of the objectives of a humanistic-social program, this development seems to us healthy.

A similar development is apparent in political science or government courses. The emphasis would appear to be shifting from a description of the institutional relationships of federal, state and local governments to a more realistic study of the various forces, like political parties and pressure groups, that have evolved to get the work of representative government done. Increasing attention is also being paid to foreign policy and our growing responsibilities as a world power. There can be little doubt that these emphases are better meeting the needs of engineering students.

Sociology and anthropology, which were once thought of as parts of the same discipline, show signs of splitting apart. The sociologist has a great deal to offer the engineering student in the analysis of urbanization and its problems, as well as in shedding light on social stratification and motivation. The anthropologist is coming to have more in common with the social historian, and as we have indicated, his findings are being incorporated into a number of civilization courses normally taught by the history department.

Courses in social psychology tend to overlap with those of sociology, both groups providing insights into the evolution of social organization. Psychology courses that begin with physiology and deal in some measure with depth psychology provide some corrective to the lack of biological study which is characteristic of most engineering programs. Courses in personality development, marriage and the family, applied psychology, etc., would seem

to us to correspond to the more highly specialized applied courses in engineering, which must often be sacrificed if a sound grounding in fundamentals is to be the objective.

3. The third specific objective listed in the Hammond Report is *"the ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English."* Here the committee found the greatest expression of dissatisfaction with actual results, possibly because results, or the lack of them, are more readily detectable here than they are in most other fields. From all parts of the country came the now standard complaint that students could not read or write adequately, and could not express themselves orally with either clarity or precision. Alumni groups and spokesmen for industry are almost unanimous in pressing for more work in English—meaning always writing and speech. Yet the non-technical studies in many engineering schools already consist almost exclusively of work in communication skills, with perhaps a course in economics as the sole concession to the remaining aims of a humanistic-social program.

The most disturbing factor in this whole "English problem" is the staggering discrepancy between effort and results. Students normally begin their schooling with a reasonable command of the English language, acquired primarily from the home. They then study English in one form or another continuously throughout the elementary and secondary grades, or for a total of twelve years. Yet it is a commonplace that colleges regard this preparation as inadequate, and the freshman English course is the closest thing we have to a universal requirement in collegiate education. On top of this, engineering schools commonly add a speech course or two and a course in technical report writing. But the complaints of inadequate proficiency still pour in.

Obviously, something is deeply wrong here, either with our definition of what it is we are trying to accomplish, or with our way of going about it. If the same amount of time and money and manpower were devoted, with such apparently disappointing results, to the teaching of any other subject in the curriculum, it would be regarded as a national scandal. Fortunately, it is not the business of this committee to solve this problem, but we can scarcely ignore it when we find in institution after institution that the lion's share of the time set aside for the humanities and social sciences is taken up by work in composition and speech. And the implications of even this assertion must be carefully qualified, for we found that, while some freshman English courses were nothing more than routine and mechanical reviews of grammar, others were obviously among the most imaginative and humane courses on the campus.

The committee recognizes that the English problem is not peculiar to engineering education, yet it suggests that engineers might well take the initiative in sponsoring a thorough-going and hard-headed study of the whole

complex matter. In the present investigation we made no such study, and will therefore merely call attention to certain principles that seem to be emerging from the many practical attempts to grapple with the problem at the local level.

The first is that students seem to fare better when they are asked to write and speak about significant subject matter that engages their interest. The usual "book of readings" that has become standard equipment in many composition courses, while often lively and provocative, characteristically covers the whole range of human interests in order to provide something for everybody. The explanation for its use is "to give students something to write about." It strikes the committee as startling that, with the humanities and social sciences being slighted for lack of time, the composition courses should be groping for "something to write about." One institution we visited was using an Anthropology text in composition, with apparently good results. Another institution has put the composition work in the junior year when students are not only more mature, but have taken enough courses so that they do not lack for theme subjects. Several institutions are now experimenting with tackling the reading, writing and speaking problem as an integral part of the whole humanities sequence. The communications skills are being developed as students grapple with ideas in the subject matter disciplines. And in some institutions this process has been extended to include the scientific and technical courses. Such experiments appear promising not only because of the functional treatment of communication, but also because of the continuing attention which is paid to these skills over a period of years and in all aspects of the student's education. The engineering faculty has its part to play in the development of competence in writing and speaking.

A second type of experiment is based on the idea that the communication work should be different from high school work in English so that the student may get a fresh look at the subject, on a more mature level. The tendencies here are to incorporate in communication courses material on semantics, logic, propaganda analysis, and critical thinking; or to consider writing and speaking in terms of purpose and function, emphasizing organization and style rather than grammatical correctness, and supporting verbal communication with work in graphical and pictorial communication; or to combine reading and writing by concentrating, for example, on the similarities and the differences between scientific prose and imaginative literature. These attempts would seem to get around the no-subject matter difficulty, and if they can be planned as an organic part of the whole humanistic-social program, they may provide useful answers to the two problems at once.

4. The fourth objective of the Hammond Report called for *"an acquaintance with some of the great masterpieces of literature and an understanding of their setting in and influence on civilization."* As a result of its

study, the committee believes that this recommendation needs to be defined more carefully and expanded to include the non-verbal arts.

At least one course in literature is a standard requirement in many humanistic-social programs. But literature is a broad term. What kind of literature should the engineering student study, and what specific goals should such a course aim at? Literary documents may be studied as historical records—as products of the social and intellectual milieu out of which they grew, or conversely as influences upon the social and intellectual development of a society; or they may be studied as types—the novel, drama, essay, lyric, etc.; they may be studied as a part of the history of ideas, exhibiting as they do the various attitudes and beliefs that men have held about God and nature and man and his destiny; they may be studied as forms of art to be enjoyed for their own sake. This list is not complete, but it may suggest that there are decisions to be made beyond the preliminary one of whether any literature at all is to be included in the program.

As nearly as our field workers could determine, the literature courses that were most successful with engineering students were those that emphasized ideas and values, as opposed to those that emphasized form or historical significance. It did not seem to make much difference whether the literature was American, British, or Greek, so long as it dealt with important ideas and was aesthetically valuable in its own right. We were told by many literature teachers that engineering students seemed particularly adept at the analysis of ideas but were less likely than other students to enter into the creative experience that is so important a part of the reading of imaginative literature.

This observation connects with another that was made by independent field workers at a surprising number of institutions. It was that, for reasons that no one is quite sure of, engineering students tend to show an exceptional interest in and understanding of music. Where opportunities are provided, engineering students play music and listen to music and discuss music, with an enthusiasm that sets them apart from most other students. Several observers reported also that painting and the visual arts seemed more congenial to engineering students that did literature. How much these impressions, insofar as they are valid, reflect a general tendency in the new generation, and how much they are peculiar to engineering students, we do not know. For our purposes it is enough to call attention to the potential interest in non-literary arts, and to suggest that those responsible capitalize on it whenever possible.

5. The fifth objective suggested in the Hammond Report was *"the development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude."* This objective, broad and general as it is, presents special problems. The committee believes that it cannot be realized merely by adding courses in religion and ethics to the curriculum. In particular the

question of inculcating in aspiring engineers the highest standards of professional ethics would appear to be a joint responsibility of the arts and engineering faculties, with the latter shouldering the major share of the burden. If the engineering faculty do not, by precept and example, show the importance of professional ethics, it is unlikely that a course in ethics taught as part of the humanities sequence will do the job.

Courses themselves will necessarily vary from institution to institution. It is clear that a number of church-connected schools will require courses in religion as a result of their basic religious orientation; and the committee believes that these courses frequently supply many of the values that in secular institutions are sought by humanistic-social programs. The committee was especially impressed with the fact that in some church-related institutions time was provided in the curriculum for both a fairly comprehensive program in the humanities *and* a four year sequence in religion. State supported institutions cannot teach religion in the same way, and must seek elsewhere for ways of giving meaning and coherence to the total educational experience. Field workers have reported, however, an increasing interest in religion and philosophy on campuses all over the country, and the committee urges that this fact be taken into account by faculty committees concerned with program planning.

A few general observations on specific courses and devices may be useful. Much philosophical material is, of course, being incorporated into humanities courses and civilization courses. The committee feels that the historical approach to philosophy can probably be handled better in these general courses, where ideas are placed in context, than it can be in the usual history of philosophy course. The problems course in philosophy appears to have considerable appeal, probably because of its immediacy, and because it can, in part at least, be related to the student's knowledge of the sciences, giving that knowledge a significance which he has not suspected it had. One instructor reported that engineering students are startled to discover that the Second Law of Thermodynamics may have philosophical implications.

More specialized courses in the philosophy of science also seem to be gaining in popularity, and field workers found at one institution some interest in the philosophy of technology. The development of such courses goes hand in hand with the increased attention being given to the history of science. We believe both should be encouraged. One word of practical advice would seem justified by our interviews, and that is that the history of science appears successful even when taken in the earlier years, while the philosophy of science would better be delayed until the student is more mature and more fully acquainted with mathematics, physics, and chemistry.

6. The final objective listed in the Hammond Report, *"the attainment of an interest in these pursuits and thus of an inspiration to continued study,"* does not refer to a particular body of subject matter, but it does enunciate

a general principle which is often overlooked. The committee believes that in all the humanistic-social work the objective must be not "coverage of subject matter" but development of interest and enthusiasm *together with* sufficient knowledge that the student may continue his reading at his leisure and with some confidence that he knows what he is doing. It is important that instructors, impressed with the vastness of their subject matter and armed with their hard-won learning, take care not to overwhelm their students with demonstrations of their own erudition. The instructor must, in effect, select the most advanced and significant concepts in his field, get them into language which non-majors can understand, and see to it that students use them until they become part of their intellectual equipment. And he must take care that students experience some success in this process as they go along, or he may lose them long before his task has been accomplished.

IV

Faced with the many complicated problems we have been describing, it is not surprising that some schools are attempting what some educators may regard as radical experiments in combining subject matter fields and emphasizing unifying concepts of the broadest sort in an effort to equip the student with conceptual bridges between traditional fields. The committee believes that work of this kind should be encouraged. There are bound to be some failures, but the problem which these men are attacking is probably the major intellectual problem of our time. The proliferation of content in all fields, while a remarkable human achievement in itself, is also one of the most frightening aspects of our disturbing age. Attempts to find unity and meaning within it should be applauded, not derided. The committee believes that even such new and relatively undeveloped concepts as information theory, game theory, and organization theory should be thoroughly explored for their possible unifying value. Engineering students who are themselves moving out to the frontiers of knowledge deserve to be taught by men who are alive to new ideas and are able to demonstrate by personal example that no man's education may ever be thought of as completed.

"The basic device that appears most promising . . . is the four-year vertical sequence. . . ."

The Problem of Arrangement

FROM what has already been said about content, it should be apparent that the order in which subject matter is presented, and the ways in which the various courses are related to each other, are questions of crucial importance. The committee believes that a student's experience with the humanities and social sciences will be more meaningful if it is a continuing one, and that he should acquire not merely isolated facts and skills but a sense of progression, and of interrelationships. His experience should be cumulative, not a series of unrelated explorations in different directions. Course should build on course, concept on concept. Only in this way can the student's humanistic-social education be given a depth comparable to the depth which already exists in the scientific and technical part of his work.

The committee strongly reaffirms the recommendation of the Hammond Report for a *"designed sequence* of courses extending throughout the four undergraduate years." That Report continues, "No existing formulation of means—of educational programs and procedures—has as yet proved to be fully adequate. . . . We believe that a year by year development of such means is one of the most important tasks before this Society."

In the years that have elapsed since the Hammond Report laid down this charge, a great deal of carefully planned and broadly conceived experimentation with designed sequences has been undertaken, and it is now possible to say that answers, both general and specific, to four basic questions of curriculum design are beginning to appear. These questions are:

1. *The question of structure:* How should the courses be distributed throughout the curriculum?
2. *The question of integration:* To what extent should courses be integrated and coordinated? What appear to be the most effective ways of integrating and coordinating?
3. *The question of adaptation:* To what extent should engineering students be treated differently from other students? In what ways can material be adapted to the needs and interests of the engineer?
4. *The question of election and diversification:* To what extent should the selection of a curriculum be in the hands of the student? To what extent should specialization be permitted or encouraged within the humanities and social sciences?

The committee believes that a discussion of these questions will give rise not to a single arrangement of courses, but to a wide variety of carefully planned curricula, each suitable to the needs and resources of a particular institution. Curriculum planning, after all, is much like house planning. A good plan must take into account the needs of those who will occupy the house and the characteristics of the locality in which it will be built. It is nevertheless possible to set up certain design principles which will be applicable everywhere. This the committee has tried to do in the following sections.

II

THE most specific question, and the one to which the clearest answer can be given, is that of structure. The basic device that appears most promising in meeting the central problem of adequate content in inadequate time is the four-year vertical sequence recommended by the Hammond Report. In one form or another, this simple but potent structural device is now in use at some twenty engineering schools. The advantages of the sequential arrangement have nowhere been fully exploited, but already very substantial progress has been made, and the committee urgently recommends that all institutions give this plan serious consideration.

A four-year vertical sequence (or a five-year sequence in five-year programs) means that the courses, usually one each term, are arranged in an ascending order from the freshman through the senior years. Many, though by no means all, curricula are able to allot this much time in addition to freshman composition. Such an arrangement has at least the following potential advantages:

1. It assures continuing contact with the humanistic-social fields from the moment the student enters college until the day he graduates. He does not "get off" his general education requirements in the first two years and then, with a sigh of relief, proceed to departmental specialization. Instead, the humanistic-social work becomes a normal and integral part of his total undergraduate experience.
2. Each course can build upon its predecessors, thus permitting some systematic, consecutive development over a period of years. Junior and senior courses can be taught at junior and senior levels, capitalizing on the greater maturity of the student, to the obvious gain of both student and instructor. A collection of merely introductory courses may, therefore, be avoided. Moreover, the most serious danger of all general education courses—the danger of superficiality—can in some measure be obviated if the later years of the sequence are properly planned.

3. Broad basic courses taken by all students may be combined in the sequence with elective courses that push more deeply in some direction of the student's choosing.
4. Finally, the planned sequence encourages everyone concerned to pay attention to interrelationships. Each course may be planned as part of a total scheme, building on what went before, preparing for what comes after. Even if the sequence is made up of traditional courses, the departments involved must decide what comes first and what follows, and each offering is bound to be affected in some measure by the logic of the total pattern. Where encouragement is given to the development of new courses, each gains strength by an understanding of its purpose in relation to the rest of the offerings.

Better motivation, better balance, avoidance of unnecessary repetition (but encouragement of useful repetition), systematic planning of the total program—all of these are potential advantages in the vertical sequence that compel the committee to see it as the most promising instrument yet devised for insuring an efficient use of the time available for work in the humanities and social sciences. The practical evidence from our field trips bears out this view. The most stimulating and forward-looking programs we studied took advantage, almost without exception, of the vertical sequence.

Having indicated our conviction that courses should be related one to another, cumulative in their effect, and extended throughout the entire curriculum, we should like to call attention to two fairly common arrangements that seem to us not to take sufficient advantage of the possibilities inherent in a planned sequence. These are: (1) the required sequence of standard courses in the various disciplines; and (2) the free elective system. Both of these schemes have serious defects as solutions to the problem of providing an adequate experience in the humanities and social sciences. Introductory courses intended for majors in the various fields are too frequently vocabulary courses designed to prepare the student for later course work. They were not planned with the non-major in mind and they are not likely to provide him with what he needs. Engineering educators who are inclined to disagree with this point should ask themselves whether the first course in their several engineering sequences would be of much use to the liberal arts student who wanted to get some general understanding of mechanical, electrical, or chemical engineering. Another difficulty with the introductory course in the four-year sequence is that it does not take advantage of the growing maturity of the student. A series of freshman or sophomore courses is likely to prove uninteresting to the upperclassman, and give to the humanities and social sciences a reputation for being elementary and inconclusive when compared with advanced technical courses.

The difficulties with the free elective system will be discussed more fully later. It is clear that an elective system need not be a mere series of introductory courses. The real difficulty is that the elective system need not be anything in particular. A free elective system shifts the burden of responsibility to the student. If there is good counselling and an adequate choice of carefully designed courses the results may conceivably be good. But the odds against its being a really meaningful sequence are so great as to raise serious doubts that the uncontrolled elective system is the most desirable arrangement.

If the committee's analysis is correct, the answer must be found somewhere in the wide range of possibilities which lie between uncontrolled election and a prescribed series of unrelated courses, in other words, *in a planned sequence which is partially or wholly integrated, or correlated, or otherwise brought into some meaningful arrangement.*

III

No planned arrangement of courses (or, for that matter, of units within a course) can avoid the problems of integration. The process, if not the name, is a commonplace in all educational endeavor. The technical curricula in engineering are integrated, as every use of calculus in physics, or every application of a physical principle to a specific technical problem indicates. This is also true, though perhaps to a lesser degree, of the humanities and social sciences. When the Hammond Report asks that engineering students be given not only an acquaintance with some of the great masterpieces of literature, but "an understanding of their setting in and influence on civilization," it is calling for an integration of historical and sociological with purely literary knowledge. In other words, if integration be thought of as meaning those pedagogical adjustments that must be made when the departments of human knowledge are used as instruments for undergraduate instruction rather than convenient divisions for purposes of research, then no serious educators can be opposed to integration *per se;* such quarrels as exist are really about what form integration should take.

Our committee distinguished four major types of integration, each of which appears to be educationally sound if properly handled. These are:

1. *Vertical integration,* or the correlation of consecutive courses in such a way that one course builds on the facts, concepts, or methods developed in previous courses. In this type of integration the traditional disciplines may be presented in separate courses, but there is a conscious attempt to relate one course to another.
2. *Horizontal integration,* or the correlation of the work in one course with the work in another course which is being taken

concurrently with it. Since in engineering education this ordinarily means correlation of humanistic-social courses with scientific and technical courses, in other words adaptation, it will be discussed in a later section of this report.

3. *Interdisciplinary integration,* or the drawing together into a single course or series of courses of the principles and data from several fields of knowledge. The commonest examples are:

    a. Courses in the humanities which draw upon literature, philosophy, music, painting, architecture, and the other arts.
    b. Courses in the social sciences that draw upon economics, political science, psychology, and sociology.
    c. Civilization courses of various sorts which draw upon both the humanities and social sciences, and even on the natural sciences.

4. *Integration of purpose,* or the use of one course to accomplish several basic objectives. Most common are the attempts to provide facts and concepts and certain skills at the same time; to put composition, for instance, into a subject matter course, or to use a composition course to teach students something about logical method and critical evaluation.

The committee believes that these various types of integration all have their uses. It also recognizes that most of them have their dangers and problems. A frank discussion of these problems should make the real educational issues clearer.

The most conservative of the schemes is, of course, *vertical integration.* Historians teach their history courses, economists teach their economics courses, literature people teach their literature courses. The values of each discipline are preserved, and the separate departments remain intact. In this situation the major problem is to insure that some coordination does actually take place, that there is in fact an integrated sequence and not just a series of courses which are related to each other on paper and nowhere else. The plain fact is that it often takes a major revolution to jar a faculty member out of a well-worn departmental rut, and the development of a correlated sequence may not be enough of a revolution. Professor Smith may still continue to teach Smith 1 and Smith 2 regardless of the fact that the catalogue now talks about Social Science 1 and Social Science 2. Nevertheless the correlated vertical sequence may be the only feasible solution in many schools. The committee believes that it can be made to work if sufficient effort is put into the job. It also suggests from a practical point of view that the development

of an interdisciplinary course or courses as a capstone to a supposedly correlated sequence will often result in a closer coordination of courses at the lower level. The single interdisciplinary course will require members of different departments to work and think together in a way quite different from that which usually takes place in a committee meeting. It will also set up a focal point toward which other courses will gradually be oriented.

The *interdisciplinary sequence* is a much more radical solution. The committee believes that the interdisciplinary sequence holds great promise, and that continued experimentation should be encouraged, but it warns that the evidence is not all in, and that the extent to which several disciplines may profitably be brought together for teaching purposes has not been established with any certainty. The complete reshuffling and re-thinking which must take place in an interdisciplinary course or sequence of courses practically insures that something new will develop. Whether that something is good or not will depend in large measure upon the ingenuity and the sincerity of the people involved. In some of the courses which the committee examined, there seemed to be a serious loss. If the student's only acquaintance with the arts is through a civilization course, for instance, he may come to think of works of art simply as documents in the history of a civilization and lose all sense of their relevance as immediate experience. This is not an inevitable result of such a combination, but it is a real danger. Interdisciplinary courses, furthermore, make heavy demands on the instructor. He can no longer rely on the notes he took in his last graduate seminar, and he must explore fields of learning outside his own specialty. For some teachers this in an insurmountable obstacle. For others it appears to provide an intellectual challenge that makes a career in engineering education more attractive than any other. The committee would here urge that if such desirable instructors are to be retained, vigorous and clear-cut administrative arrangements must be made to insure their academic and professional advancement.

Courses which attempt to *combine several purposes* also require comment. It is perfectly clear that there is a limit beyond which such combinations cannot go. Given so many hours for class work, and so many hours for preparation, only a certain amount can be done. The committee can conceive of a course in surveying, for instance, which would deal with the whole history and theory of measurement, would break over into the law of property, and would end by raising the most penetrating questions about man and his uses of the earth; it doubts, however, whether the student would get much practice with the chain and transit. But this extreme example in no way invalidates the idea of combining various purposes in one course. Many courses are thought of as giving students either skills and techniques, *or* facts and ideas, *or* new interests and attitudes, *or* new experiences. Yet several of these purposes may often be skillfully combined in a single course without in any way weakening the value of the course. Why should writing and speaking, for

instance, be taught only through skill courses in composition, speech, or communication? Why should students not learn to write and speak while they are writing and speaking about a particular body of subject matter? The committee found many examples of this kind of integration, some of them apparently quite successful: a community survey project, for example, which gave students experience in analyzing a total community, required them to talk with a great variety of people, forced them to apply principles of economic and social analysis and also made report writing and speaking in conference situations a functional part of the entire project. Other programs integrate writing and speaking with humanities courses and sometimes with technical courses as well. Others include in composition courses text materials which provide an introduction to later work in the humanities and social sciences. Others use courses in language to compare the methods and attitudes of the scientist and engineer on the one hand and the artist on the other. In all these arrangements there are clearly two dangers: (1) that the skill portions of the work may actually be neglected; and (2) that the combination may be unnatural, forced, or confusing.

IV

WHATEVER the kind of integration, success involves a re-thinking of subject matter on the conceptual level. It is not enough just to throw things together in new combinations. There must be some kind of intellectual framework which will give meaning and continuity to the whole experience. The committee cannot report that it found any single, generally accepted intellectual framework applicable to the whole of the humanities and social sciences. But it did find a number of promising concepts in actual use with apparent success. Among these are the following:

1. *Historical-cultural concepts,* as in many civilization courses.
2. *Concepts of form and function,* as in many courses which attempt to combine the various arts, and even other forms of communication, into a meaningful whole.
3. *Concepts of socio-economic structures,* as in courses which see all human activity reflecting itself in social organization.
4. *Concepts of man.* These may range from evolutionary and anthropological concepts to strictly religious ones.
5. *Concepts of method,* as in programs which compare the methods of one field with those in another.
6. *Problem-solving concepts* which may begin with the notion of man as a problem-solving animal and relate all his activities to this idea, or may concentrate on major issues of the past and present.

This list is by no means exhaustive, but it reflects the serious level at which engineering educators are struggling with this difficult intellectual problem. Out of careful experimentation may well evolve a variety of usable and interrelated concepts comparable to the basic concepts which already exist in the natural sciences. Experimenters must, however, recognize the pitfalls which surround such an undertaking. Most serious of these is perhaps the tendency toward premature commitment to a particular set of concepts. The committee believes that there is as yet no satisfactory unified field theory encompassing the humanities and social sciences, yet on some campuses men who have won through to useful integrative concepts have become so enamoured of them that continued research has ceased. It is the old story of the revolutionary turning conservative. On the other hand, there is the opposite danger that the instructor in his zeal to remain impartial, and tentative, and open-minded will end up communicating no principle by which affairs may be judged. He may become so flexible as to be, in Irving Babbitt's phrase, positively invertebrate.

V

A FINAL word must be said about the idea of deferring the real synthesis, the real integration, until the end of the program. We have already said that we believe the capstone course may be a useful integrative device ond also a useful means of achieving greater coordination among departmental courses. In some schools this final synthesis takes place in an interdisciplinary course. In others it occurs in what is essentially a philosophy course. In still others a Contemporary Civilization course, or a Great Issues course, may be used to draw the various threads together.

In the face of such variety, why not turn the job over to the students? In talking about integration on our field trips we constantly ran into the argument that integration was all right but after all it must take place in the mind of the student. This is such an obvious platitude that we would not mention it if we did not believe that it is actually being used to the detriment of necessary developments in some programs in the humanities and social sciences. Of course integration must take place in the mind of the student if it is to be effective. So must all learning. And there is furthermore no single integrative principle. Integration must, nevertheless, be prepared for, and arrangements must be found which will encourage it to take place. The mere placing of two related facts within the same consciousness does not, strangely enough, insure that that consciousness will in fact relate them. This should be clear to anybody who has watched what students do, or rather do not do, with mathematics and physics in their engineering courses. The *idea* of relationship must be established. Integrative concepts must be used until they become familiar. If this is done it is possible that students can be

left to take further steps in integration on their own, as their experience grows. This is one of the things we mean when we say that true education is a lifetime process.

VI

Is the engineering student a distinct species? Should he be treated differently from other students? Should the arts departments be asked to develop separate courses especially designed for him?

These questions we asked everywhere we went throughout the country, and the responses they evoked were frequently quite violent. They also revealed one of the basic splits in thinking between the engineering faculties and the arts faculties, because on the whole the engineers were favorable to special treatment, while on the whole the arts people were not. "Any request for courses other than those developed by the arts department for arts men is a request for adulteration and is to be resisted to the death," a liberal arts department head is quoted as saying to our field workers. "If the engineers want culture they can come and take what the arts college offers." In fairness, it must be added that a minority of engineering faculty spokesmen appear to share this view, though usually on the ground that the benefits to the engineering student of rubbing elbows with contemporaries whose interests differ widely from his own far outweigh such advantages as stem from courses designed with engineering students in mind.

On the other hand, it is precisely this attitude on the part of the arts faculties which has driven a number of engineering schools to establish their own humanistic-social departments, or their own departments of English, or to use other less radical devices for getting the kind of instruction they seek for their students. The evidence from this study is that when this is done the results are gratifying, at least to the school of engineering. At one institution where a department of English and Humanities had been an integral part of the engineering school for over thirty-five years, we were informed in no uncertain terms by the engineering faculty that they proposed to continue the arrangement for at least the next hundred years. We must report also our observation that at the institute type of engineering school, where the humanistic and social science departments deal almost exclusively with engineering students and in consequence readily adapt their courses to the needs and interests of such students, complaints about the humanistic-social work were at a minimum.

We confront here, then, a problem of considerable gravity. Our evidence indicates that courses specially designed for engineering students are in the main successful, at least in winning the support of the engineering faculties and the engineering students. On the other hand, such courses are usually violently opposed by the departmental representatives of the humanities and social sciences. In addition, the administrative problems involved can be-

come very serious indeed, and we can scarcely blame a university administration for shuddering at the thought of separate departments, or even separate courses, for each of the professional and pre-professional schools on the campus. Furthermore, the professional careers of arts men who join such captive departments are often jeopardized, and it is not easy to maintain a top-flight faculty. In view of these considerations, the committee must regard the establishment in the school of engineering of separate departments for teaching the humanities and social sciences to engineering students as a device of the last resort, to be adopted only as a solution to extreme local conditions.

Whatever the administrative arrangements may be, however, the educational issues raised by attempts to adapt the subject matter of the humanities and social sciences to the needs of engineering students are fundamental, and the committee believes that a certain amount of frankness is required if they are to be satisfactorily resolved. Some fifteen or twenty years ago there was a considerable rash of courses in Engineering English, Engineering Economics, Engineering Psychology, etc. It is our opinion that many of these courses did represent attempts to water down the subject matter and soften up the grading for the sake of engineering students. There is evidence that many courses in Engineering English, for example, were established because too many engineering students were failing freshman composition. Whatever the facts, such courses at least got the reputation of being devices for lowering standards, and it is this reputation that lies behind much of the violence of the opposition to adapting courses to engineering students. Perhaps the engineering faculty can better sympathize with this point of view if they consult their own opinions about courses in mathematics for business administration majors, courses in physics for nurses, or courses in chemistry for arts students.

This committee vigorously opposes any attempt to devise courses for engineering students that do not meet the highest academic standards. It calls attention to the bad repute which courses in the humanities and the social sciences with the prefix Engineering have acquired. It suggests that the prefix be abandoned in proposals to and in discussions with the arts faculty, and that particular pains be taken to demonstrate to the arts faculty that when special attention is sought for engineering students this does not mean a request to lower standards. There is certainly no need for it; engineering students are among the ablest on any campus, and at several institutions we ran into the complaint that the trouble with the liberal arts courses was that they were too easy, too leisurely for engineering students who were accustomed to heavy assignments and to systematic work schedules. One advisor informed us that he was an enthusiastic supporter of the humanistic-social program and that he required all of his students to take at least one course in these fields each term. But his reason was not entirely reassuring. It

was that he felt his students were carrying such heavy and exacting loads that they deserved some recreation, some soft spot in the schedule where they could relax and loaf a bit. While this is admittedly an extreme example, we believe that, whatever may have been true in the past, the pressures now for courses designed with engineering students in mind come from the dual desire to get better motivation and to pack more real substance into the limited time available.

If the usual introductory courses in English Literature, History, Economics, Philosophy, Psychology, etc., were consciously designed as general education courses for the non-specialist, a great deal of the demand for special treatment for engineering students would be removed. What leads to this demand is not so much the feeling that the engineering student is a separate species as it is the feeling that he is most certainly never going to major in the humanities and that usually the course he takes is the last formal exposure to the subject matter he is likely to get. He frankly seeks what the intelligent layman ought to know about the subject involved. Yet too often the initial courses are designed, either consciously or unconsciously, as introductory to later courses taught by the same department. It is assumed that the student will go on to additional study, and this seriously affects the nature of the offering. Most of the members of the department involved started in the field the same way, and this accounts in part for their feeling that any other way is bound to be inferior. What is forgotten is that they did go on to advanced work, while few engineering students ever will.

Fortunately, this situation is now becoming generally understood, and fortunately also, the engineering student is not alone in his need for a terminal course designed to provide a layman's understanding of a given subject. It has been estimated that even in a great university over eighty per cent of the work of the English department is in service courses for non-majors, and the ratio will probably go higher.

It appears to this committee, however, that most general education programs devised with arts students in mind, admirable though they may be, still possess two defects from the point of view of the engineering school. First, they seldom take cognizance of, or advantage of, the scientific and technical interests of engineering students. Second, they usually require considerably more time than the average engineering curriculum is willing to spare, although in this respect there are several notable exceptions where engineering students are, with apparently good results, taking the same general education program that is required of arts students.

This situation suggests a long range solution that appeals to the committee as both feasible and desirable. It is to join forces with other professional and pre-professional groups on the campus whose problems are at least roughly comparable to that of the engineering school. Pharmacy, nursing, business administration, forestry, agriculture, textiles—the list will vary at

different institutions, but on most campuses there is a considerable body of students with much the same problem: crowded curriculum, scientific and technical and practical interests, yet with a real need to possess themselves of the values and insights which the humanities and social sciences can offer. Administrations that would understandably shrink from the prospect of special courses and special programs for every special group, will find it more reasonable to visualize a single general education program designed (with room, of course, for individual variations) for all professional and pre-professional groups.

We are glad to report that moves in this direction are already apparent on several campuses. Where the engineers have established workable and attractive humanistic-social programs for their own students, other schools are asking to come in on the program. Local political and administrative considerations sometimes prevent it, but the possibilities are there, and it seems to the committee that this is a practical direction in which to move. So long as the engineers take the lead, the interests of their own students will undoubtedly be taken care of, and in addition they will come to receive some of the benefits of working with students in fields other than their own.

This solution seems to us to hold promise not merely because it solves some practical problems, but also because it rests on the sound assumption that engineering students are not a separate species. There is every reason to believe that the difficulties of incorporating a sound humanistic-social program in the various engineering curricula are as acute as they are in any of the other professional or pre-professional curricula. As progress toward a solution is made in engineering, therefore, adaptation or modification with other groups in mind should not prove too difficult.

VII

THE committee has already indicated its objections to uncontrolled election as a solution to the problem of providing engineering students with an understanding of the humanities and social sciences. But there is a vast difference between uncontrolled election and controlled or planned election. There is unanimous agreement that a certain number of hours of work in the humanities and social sciences should be required. But there is less agreement about what portion of this work should be planned by the student and what planned by the faculty, or the related question of the desirability of diversifying programs in the humanities and social sciences vs. the desirability of encouraging specialization even in the limited time available.

Present practice throughout the country ranges from one extreme to the other, with what we judge to be the most successful programs striking some compromise in which one or two or even three basic courses are required of

all and the student is then allowed some election. After careful consideration, your committee concludes that while a certain amount of election may serve a useful purpose, the advantages of a *planned sequence* of courses are so overwhelming that *only electives which are a part of the plan should be allowed.* This is so important (as well as controversial) a recommendation that we feel some obligation to explain in detail the reasoning that lies behind it.

Those who argue for a maximum of free election do so on several grounds. There is what may be called the *argument from democracy.* This takes two forms. Negatively, it is argued that it is undemocratic and authoritarian to impose any rigidly prescribed pattern on free students. More positively, it is argued that if students are to become mature members of a democratic society, they must learn to make their own choices and accept the consequences. In this view, even their mistakes form an important part of the educational process.

A second position may be called the *argument from individual variation.* According to this view, the great variety of student interests and aptitudes should be recognized and encouraged. Attempts to fit everyone into the same dull mold should be resisted. Furthermore, it is argued, the motivation is better in courses the student himself elects. There is always a certain amount of natural resistance to being told what you have to do, and the vitality of the educational experience suffers in prescribed courses.

But the most serious argument for maximum election rests on quite different grounds. This may be called the *argument from too much knowledge.* Starting from the undoubted fact that vastly more knowledge is available than any one man can now in a lifetime assimilate, and that any running survey of it can lead at best to superficiality, at worst to total confusion, holders of this view maintain that students should acquire as full and penetrating a knowledge as possible of at least one area outside their field of specialization and that the choice of area should be their own.

The committee recognizes that these arguments have merit, and believes that no system of requirements in any educational institution should be so stubbornly administered that adaptations to individual needs cannot be made. It assumes that all recommendations contained in this report will, if accepted, be subject to wise and flexible interpretation and administration. But it also believes that an uncritical acceptance of the principle of election is now undermining much of the usefulness that can reasonably be expected from the humanities and social sciences.

The argument from democracy seems to us essentially specious. The engineering student has exercised a choice in selecting engineering and also in selecting a particular branch of engineering. But having done so he has committed the planning of his strictly technical work very largely to a faculty. If his education is a whole unit, however, and the humanities and

social sciences are a structural part of it, it follows that the sequence of courses in these subjects should also be planned. We suspect that some at least of the argument for a maximum of free election is really based on a feeling that the problem cannot be solved by the faculty anyway. It is too complex; there are too many variables. But if the faculty with its experience cannot solve the problem, how can it expect the student to do so when he often barely knows what the course names in the catalogue mean?

The argument from individual variation and the argument from too much knowledge are, however, more serious. If the student can make a wise choice, he may feel better satisfied, better motivated toward the course he has selected, simply because he has had a chance to do the choosing. And it is certainly true that concentration in a particular field will give the student a better sense of at least one non-technical subject than he could otherwise acquire.

While the committee opposes uncontrolled election, it recognizes the possibility of limited or controlled election as a planned part of a planned program. Such election, it feels, should begin only after the student has had two or three years of carefully coordinated work so that he will have some idea of what he is actually electing. And the electives themselves should be thought of and planned as approximately equivalent paths to similar general goals. Given reasonably specified objectives and several courses that may reasonably be expected to lead to these objectives, there is no reason why the student himself should not be allowed to decide which course most appeals to him. We must, however, report our observation that the conditions just stated are very seldom present in the day-to-day operation of most elective systems. The actual criteria used in choosing electives appear all too often to be convenience in scheduling, rumors of easy assignments, high grades, and similar less-than-academic considerations. It is apparent that if limited elective systems are to fit the need for planned curricula, they must be scheduled in such a way that mere convenience does not become the basis for a choice, and they must be planned so that they not only do roughly equivalent jobs but also make comparable demands upon the student. This is a difficult operation, but not, the committee thinks, an impossible one.

Candor forces us to admit that one of the arguments for controlled election has less to do with the needs of the student than it does with the desires of the faculty and the problem of getting and keeping good instructors. In routine or elementary programs (and there are many of them) many faculty members prize very highly the privilege of giving an elective course which will diversify their own programs and give them contact with more mature students. Much of this problem is solved for teachers in coordinated or integrated programs, but even in these, there are individual faculty differences which it may be well to recognize.

One final word about election: At a number of institutions, electives in the humanities and social sciences are in competition with electives in tech-

nical subjects. This amounts to letting the student decide not merely which humanistic-social course he will take, but whether he will take any. We believe that such a decision should be in the hands of the faculty. Even where a free elective system is favored, the minimum number of hours to be taken in the humanities and social sciences should be specified. (Where this has been done, our field workers report the growing use of a fascinating addition to the lexicon of educational jargon. Courses which a student takes to meet the humanistic-social requirement, but which he himself is permitted to choose, are called *required electives!*)

". . . the full support of both engineering and arts faculties will produce programs more imaginative and effective than those envisaged by any single individual."

The Problem of Administration

THE importance of the administration in initiating and fostering a workable humanistic-social program can scarcely be over-emphasized. Although curriculum development is one of the traditional prerogatives of the faculty, jealously guarded in most institutions by faculty committees and by faculty control over curricula, it is our observation that vigorous administrative leadership and backing are always necessary. At every institution where a lively program is under way we found that there had been one or more administrative officers—presidents, deans, department heads—who had worked hard in laying the groundwork and in seeing to it that the necessary faculty discussions were pushed forward. At institutions where little had been done, it was usually apparent that the key administrative officials were not seriously interested. One of our field reports contains the following terse summary:

> Increasingly it strikes the present writer, as it has his team mates, that the key to the Humanistic-Social situation *anywhere* is the top Engineering administration. If this administration wants progress, it will take the steps (sometimes painful) necessary to produce it; if the administration is satisfied with the *status quo*, nothing is going to happen.

The administrative problems will, of course, vary widely with the type of institution involved, affecting as that does the fundamental relationship of the engineering and the arts faculties. They will vary too with the nature of the administrative arrangements within the engineering school itself—with the question of whether the departments are strong and autonomous, for example, or whether curriculum is planned on a school-wide basis. Faced with these obvious practical variations, the committee can do only what it has done in earlier sections of this report, namely, set down certain principles that seem to emerge most clearly from our study of how programs were initiated, encouraged, and developed in various types of institution.

The basic principle, which has already been made clear by our earlier comments, is that administrative arrangements must be aimed constantly at getting joint support for the program from the engineering and the arts faculties. The engineering group can sap the strength of the program unless it understands its purposes and feels itself to be identified with its progress.

The arts faculty can sabotage, consciously or unconsciously, the best laid plans, if it feels its interests and its point of view have not been consulted.

Joint planning is easier to accomplish on paper than it is in actuality. Our observations would lead us to believe that patience as well as administrative skill is required. Faculty members are notoriously independent characters (Carl Becker has defined a professor as a man who thinks otherwise), and time is required if they are to be brought together in a concerted effort on a common enterprise, particularly if that enterprise involves, as it frequently does in this case, unorthodox arrangements of courses and subject matter. It is not accidental, we think, that humanistic-social programs seem to be more highly developed in the independent technical schools than elsewhere. The essential reason is that in such institutions the engineering and arts faculties are more closely identified, and the departmental structure of the humanities and social sciences is less strong than it is in the large university system.

Yet the problem of developing interest in a sound humanistic-social program is essentially the same problem that faces the engineering administrator in other aspects of program development: how to get the faculty to consider the problem seriously and with enthusiasm. The committee found, however, that the problem of the humanistic-social program is particularly complicated in that there are two faculty units to be considered in the planning, and that both must be drawn into the deliberations early if success is to be achieved.

How this is to be done depends upon the basic administrative pattern of the institution, and here, of course, real differences were found. The problem in the large university with separate schools of engineering and arts, both relatively autonomous, is a far different one from that of the technical school where the functions of the humanistic-social departments are more clearly defined. Part of the difficulty appears to lie in the different modes of thinking of the two faculties; part of it appears to be due to the lack of close liaison between the two groups. Our study has shown, however, that independent work by either group is not readily accepted by the other, and if a split appears, battle lines form, opposition to the program becomes fixed, and the results are negative. Both units must accept the program with some enthusiasm.

Reports of field workers indicate that the most common cause of unsuccessful programs is unilateral planning by the engineering faculty. Too often the responsibility for program development has been given to a planning committee or curriculum committee of the school of engineering, and the arts faculty has been ignored. In this event, even though the arts faculty members have been called in for consultation, a resentment is likely to develop which may grow into overt opposition. Ways must be found to insure that the

people responsible for the teaching in the program feel that they have had a genuine part in the planning so that there is a real identification of faculty with the program they are teaching.

Various schools have solved this problem in various ways. In some instances the general education portion of the curriculum has been planned on an institution-wide basis, following the recommendations of a general faculty committee, usually appointed by the president. If the recommendations really come from a good faculty committee, this method usually succeeds in enlisting faculty interest and support. However, this approach means that no special program exists for the engineers, and it is usually this group, of all the schools, which is least sympathetic with the total program. Only in institutions with a long history of liberal tradition will the engineering faculty enthusiastically endorse such a general program, detached from the professional program with which they are intimately connected.

II

WHERE a special program designed for engineering students is sought, the methods of achieving it again depend upon the organization and relationship existing between the two faculty groups. Where the humanistic-social faculty is a service unit closely connected with the engineering faculty, no serious problem exists. The two groups are already closely allied in interest, and joint deliberations are relatively easy to arrange. Where, however, the two separate faculties exist under independent administrations, and with separate objectives, the problem becomes more complex. The committee has seen two solutions, both of which appear to work if carefully handled. If relations on the higher administrative levels are congenial, it is usually possible for the dean of engineering and the dean of arts to get together on the appointment of a joint committee to study the problem and to make recommendations to both faculties. If the gulf between the two schools is wide, the dean of engineering may (with the approval of the dean of arts) detach an interested and sympathetic man from the arts faculty and assign him to the problem of organizing a joint committee for planning and operations in this area. Extreme care must be exercised in choosing this liaison man: he must be a person whom both deans trust implicitly, and he must have sufficient personal stature and professional reputation to be respected by both the engineering and the arts faculties.

Once joint discussions are underway in a serious manner, the administrators should leave the faculty to carry on with the development of the program. Assistance should be given when requested, but the major decisions, if they are to be convincing to the faculties, must be made by the faculties. Our reports carry numerous instances of bad feeling generated because the joint committee was not permitted to function as a committee, but was ex-

pected to endorse a previously-planned program sprung full-blown from the brain of the dean of engineering or of arts. In this regard, the committee is more convinced than some deans seem to be that the faculties are both willing and able to carry on an assignment as important as this. Our study indicates that the full support of both engineering and arts faculties will produce programs more imaginative and effective than those envisaged by any single individual.

Though the administrator must rely on the faculties for planning, he cannot relax his interest in overall ends and means. As various programs now in existence testify, there is some tendency on the part of faculty committees, when the pressure is relieved entirely, to act hurriedly to get the job done, or to let the deliberations degenerate into political bartering at the expense of both the educational philosophy and the interests of the student. Curriculum planning, with so many possible channels open to explore, is a difficult assignment, and there is no easy solution. The administration must keep a watchful eye on the deliberations, and be always ready to reiterate the major objectives of the program and to remind the faculty that education is designed for the student rather than for the convenience or tradition of the faculty.

Formulation of a coherent and effective program is difficult enough, but the major task of administration comes after the program is initially adopted and put into effect. Every means must be employed to create an atmosphere in which the program can flourish and to follow through on its continued development and improvement. A reorganization of the teaching personnel, to be discussed later, may be necessary. At the same time, the program must remain under continued scrutiny to see that the objectives are being met as effectively as possible. If necessary, the program must be modified to meet the objectives, or the objectives must be reconsidered in the light of actual experience with the results.

This reconsideration of program and objectives is again essentially a faculty function. In this review, as in the planning, general faculty identification with the success of the work is indispensable. If the program developed breaks into units, it is administratively essential that some one individual be responsible for each unit. But the faculty must fit the parts into the whole and see that they continue to function in the role for which they were established. This calls, in most institutions we visited, for a continuing joint faculty committee—an advisory committee or an operating committee, usually the original planning committee with some changes to include teaching personnel from the program—to carry out the necessary continued evaluation. How much authority is to be vested in this committee depends entirely upon local traditions and the difficulty of their problems. But again experience with actual programs has shown that this is not a perfunctory committee to be casually appointed. Where the committee review has been intimate, including discussions of texts, class visitation, student interviews, and faculty

discussions, the program has been dynamic and increasingly effective. Where the committee has been detached or uninterested, the program has tended either to ossify or to break up into unrelated parts, losing entirely its central objectives.

Countless other difficulties will arise to plague the administrator, but most of these will be connected with the central problem of how to get and hold the most effective teaching faculty possible for the humanistic-social program. The committee holds that next to planning, staffing poses the major problem of administration.

III

No matter how carefully a program may be thought out, it is obvious that it cannot achieve the desired objectives if the instruction is poor or indifferent. The committee does not join those who feel that the content of the program is immaterial so long as the instruction is good. We have already indicated our belief that planning is vital and that subject matter drawn from the humane and social disciplines is indispensable to the education of the professional engineer. But we must add that imaginative and sympathetic instruction is equally indispensable.

Engineering schools here confront a practical problem of considerable magnitude. How can they attract and hold able and inspired instructors in the humanities and social sciences? The dilemma may be simply stated: if a separate staff is recruited (whether attached to the school of engineering or not) the instructors involved must ordinarily sacrifice, or at least jeopardize, their professional futures in the special departments in which they have been trained. If, on the other hand, the staff is drawn from established departments with other interests, there is bound to be, at best, a division of interest and loyalty, at worst, an overt resentment at being asked to teach undergraduate engineers. If the program has been planned jointly as we have recommended, this dilemma may not be too serious, though it is still to be considered.

Our investigation shows, as anyone might have anticipated, that the best instruction comes, with few exceptions, from a staff that understands and likes engineering students. Very little is accomplished by an instructor who wishes he were doing something else, or who regards himself as a martyred missionary among technically-minded Philistines. Rare indeed (not more than two or three on a large campus) are the exceptionally great teachers whose appeal is universal, and who can educate in spite of every adverse condition. As a result of its investigations, the committee is convinced that *able and enthusiastic instructors can be obtained if they are afforded professional careers comparable to those they might enjoy in an established and specialized department.* Salary and tenure must, of course, be comparable, but the committee holds that these are not the decisive factors. More im-

portant are the opportunities for professional growth for this segment of the faculty—opportunities for experimentation, research, and personal development.

It appears to the committee that schools of engineering possess largely unexploited resources for attracting to their courses top-flight men in the humanities and social sciences. The special problems of teaching the humanities and social sciences to engineering students provide an attractive challenge to the right kind of instructor. Further, many of the ablest men in the humane and social disciplines are deeply perturbed by the critical problems the human race is facing. They may feel that our technology has outrun our mastery of the social skills, and that unless the full impact of our humane and social knowledge is brought to bear on the scientific and technological leadership of our civilization, civilization itself is doomed. The opportunity to influence the young men who will so obviously be in positions of critical responsibility tomorrow is one that will attract those most deeply devoted to the values inherent in the humanities and social sciences. If satisfactory arrangements for professional advancement can be made, such an opportunity will seem to many to be more attractive than the prospect of a career devoted to producing scholars more or less in one's own image. A large number of instructors in the humanities and social sciences who deal exclusively with engineering students informed us that they had no desire to return to the arts college where the students were already essentially in agreement about the value of liberal studies. The engineering student, who demands that the values of the humane and social disciplines be demonstrated, proved more stimulating.

The instructor in the humanistic-social program must feel that he is working in a program worthy of the disciplines he has been trained in, and that he is developing personally and professionally by his participation in it. He must not see himself as sacrificing his own interests by doing work which is of secondary importance or is rewarded as if it were. Success in teaching in the humanistic-social program merits and must receive professional recognition. The administration of the program proposed for each institution must be carefully thought out to provide these rewards; the teacher of engineering students must not have his academic fate left solely in the hands of a department whose major interests lie elsewhere.

The needs of the humanistic-social program, content-wise, indicate that several types of research not normally embraced by specialized departments may be stimulated. Research on the effectiveness of the program—of its contents, of its concepts, of its impact on the students—could have an immediate value which the researcher could observe. Some of this research could be conducted by every individual teacher; some of it by every contributing department. Research in experimental courses and approaches to general education under controlled conditions could also be stimulated among

the faculty. A dynamic program of research and evaluation can help to strengthen both the courses and the staff.

Many faculty members will prefer a more academic approach to research, but the humanistic-social program provides new fields of investigation here, also. If an approach on an integrated basis is made, as the committee recommends, there are countless areas in which much real scholarship must be expended before the basic problems of interrelation are solved. Here the mature scholar is brought face to face with the limitations of his knowledge, and must explore new areas with real insight and understanding. Usually he must read widely and wisely in at least one allied field, and he must knit together the best that is known and thought in both areas. Research into the relationship of apparently diverse ideas should attract and challenge the best scholarly minds, and stimulate the kind of teaching that the humanistic-social program must have if it is to awaken the minds of young engineers.

There are a number of institutions in which the liberal arts faculty have only undergraduate engineering or science students to deal with, and in consequence are compelled to sacrifice the stimulus of teaching advanced courses and graduate students. Where this is true, special incentives to continue writing and research may be necessary. Travel funds to permit attendance at the meetings of professional societies need to be supplied. One institution reports that monthly meetings of the humanities staff at which papers are read and discussed has proved helpful, with the staff itself providing the sort of stimulus a seminar is supposed to provide.

Nothing that has been said about the opportunities for special research that are available to the man who teaches humanities or social sciences to engineering students should be taken as meaning that the normal and traditional fields of scholarship are in any way closed to such a teacher. Our suggestion is only that additional challenging possibilities open themselves to the arts man on an engineering campus. In this connection we must report the comment of the head of a chemistry department in a technical school where no degrees in chemistry were granted and very few on his staff had any direct contact with graduate students. He had built what was obviously a superior staff, most of whom were actively engaged in research and had enviable lists of publications. When asked how this was accomplished in the absence of the usual academic stimuli, he reported that he was careful to explain the circumstances to each new member of the staff, adding that full facilities for research were available and every stimulus to research provided, with the single exception that the staff member would have to do his own research instead of letting graduate students do it for him!

Still another need is felt by the serious teacher of the humanities and social sciences: he must establish a close relationship with some of his students and be able to see his influence on their thought. There is still some carry-over of the old master-apprentice relationship which cannot be ignored when

the stimulation of the faculty member is being considered. Some few individuals can derive satisfaction from lecturing to a sea of anonymous faces day after day, but these are unusual souls. Most teachers like students and want to know them and follow their growth and development. It is this instinct which leads to gasps of horror or laughter when teaching by closed-system television is first broached at a faculty meeting. And it is probably true that much of the best teaching is done on this man-to-man basis; school after school reiterated its faith in the "good teacher", and when pressed came down to this close association of faculty member and student as the heart of the matter. When programs are devised and schedules arranged, each instructor should be given some work involving relatively intimate contact with his students—at least one small discussion group where he can bring the full impact of his scholarship and wisdom to bear on students whom he understands and likes.

To sum up, the staff assigned to teach in the humanistic-social program must be well trained professionally, alert, and, above all, interested in the problems of teaching engineering students. Instructors should be granted time for research and deliberation, and should have direct contact with some small number of students for the intellectual satisfaction of both. These professional opportunities, beyond salary and tenure considerations, should be more than adequate to insure a diligent and enthusiastic teaching faculty for the humanistic-social program.

"Reorganizing an academic curriculum is like trying to move a graveyard."

The Problem of Time

In previous sections the committee has made a number of recommendations about philosophy, course content, course arrangement, and administration. But it has not yet tackled the question which to many appears of supreme importance: how much time will all this take, and where is the time coming from? The committee is inclined to discount the significance of these questions and to relegate them to last place in its consideration, but many correspondents have indicated that this is the one thing they want to know, and they want not a general answer but a specific one. They will not be satisfied with the statement that if the humanistic-social program is truly worthwhile, time will be found to accommodate it.

On the other hand, the committee feels strongly that tables setting forth data on median contact hours and the percentage of time allotted to humanistic-social studies, based on the evidence we have, might not only be meaningless, but actually misleading. In the first place, we think the significant thing is not credit hours, but the proportion of the student's total time devoted to work in the humanities and social sciences. We have very little evidence on this crucial matter. Second, the diverse methods of calculating contact and credit hours, varying ways of computing the hours required for graduation, substitution of ROTC credit for humanistic-social work, plus uncertain information about what is required and what is optional at many institutions, all conspire to make such figures as we have unreliable. Finally, definitions of what constitute humanistic-social studies vary so widely that any quantitative statements are bound to be deceptive. Our field workers were instructed to accept in each institution that institution's own designation of what constituted humanistic-social courses. Designations, as we expected, varied widely, and included, in one institution, ROTC classwork, in another a course in electrical engineering taken by mechanical engineers. In view of these considerations, it seems to us that the reasonable thing to do is to restate a principle and hazard a generalization.

The present committee reaffirms the basic recommendation of the Hammond Report that the humanities and social sciences be given "a minimum of approximately 20% of the student's educational time. This allotment should be at least equivalent to one three-hour course extending throughout the

curriculum, and on the average somewhat more." Our evidence indicates that a majority of schools do not measure up to this standard, and that even when every course that anyone chooses to call humanistic-social is included, the national average is something less than 17%. (See also the study by the U. S. Office of Education, referred to on page x, which concludes that 17% is approximately the correct figure.)

Far more important in our opinion than a statistical report on the *status quo* is the presentation of concrete suggestions about time. We believe the problem of time can best be discussed under three headings: (1) the efficient use of time within the humanities and social sciences themselves; (2) the efficient use of time in engineering and science courses; and (3) a realistic handling of the ROTC problem.

II

THE committee has already made a number of recommendations which have a bearing on the efficient use of time within the humanities themselves. These recommendations have been offered on other grounds, which the committee believes constitute the best reasons for their acceptance; yet their time-saving value is unquestionably important, and may unconsciously have influenced the committee in their favor.

1. The first recommendation concerns the composition or communication problem. The use of 25% or more of the time of the program in the humanities and social sciences for work that is largely at the high-school level is very difficult to defend. Undoubtedly, serious college-level work in communication can be carried on efficiently in courses in the humanities and social sciences; it can also be carried on efficiently in the scientific and technical program. A number of schools are now doing it this way with apparent success. Students who are unable to express their ideas in understandable fashion must be provided for in some way, either by non-credit remedial work or by continuing clinical assistance. The size of the problem varies in different institutions, and no single solution is applicable everywhere. The committee feels that the important thing is to recognize that the problem of bringing the students up to college level should not entail the giving of college credits, though advanced communication of college caliber can be taught as part of the content courses. The true corollary of this statement is that it *must* be taught in these courses. The committee is not arguing that it should be neglected.

Many schools also require an upper-level course in writing, usually taught by the English department, but sometimes by the technical departments. The reason commonly given for placing such a course in the later years is that by then the students have something to write about, the something generally being technical. The committee believes that where this course does deal

with technical material, where it is in effect a technical writing or a report writing course, it should not be considered as part of the humanistic-social program regardless of whether it is taught by the engineering departments or the English department. This is the kind of follow-up work in communication skills that may be essential, but in the interests of saving time, the committee suggests that such programs be allied closely with the content of some engineering course and incorporated in it.

This does not mean that an upper-level communications course may not have considerable value in both content and method to the humanistic-social sequence. As a matter of fact, it might conceivably furnish the capstone to the program by tying together the technical with the humanistic-social work. A community survey course like the one previously mentioned, and described in more detail in the Appendix, places heavy emphasis on the organization of humanistic-social material for specific purposes, and its effective presentation may call on the student to integrate his scientific and technological knowledge. Projects of this nature may well be an efficient solution to upper-level work in communication.

2. The second recommendation concerns vertical and interdisciplinary integration. When each course must make a new beginning, since the instructor cannot assume that the student has any relevant background for the work, much time must be spent in an elaborate introductory section which, in the planned sequence, can be dispensed with. The fully integrated sequence has an additional advantage in saving time which is not quite so obvious, but is just as real. In separate courses in the several disciplines there is an implicit assumption that subject matter falls naturally into neat blocks of twelve or sixteen weeks, or in multiples thereof. If an instructor has sixteen weeks for a particular body of subject matter, he will take sixteen weeks whether he really needs it or not. If he needs more, he cannot get it. If he needs less, he cannot take it. In an integrated sequence, even without complete reorganization, the essential subject matter may be discussed in seven weeks or seventeen weeks, or whatever number the subject matter makes appropriate. With the group planning which is essential to the integrated sequence and with the super-abundance of content from which to select, there is little danger that the teacher will be permitted to spend more time than his materials justify. Small units of time can thus be saved which will permit more vital subject matter to be included. In composition, too, in those schools where direct instruction in composition is felt to be essential for everyone, the integrated sequence offers a reasonably effective way of saving time. Instruction in the basic skills can be given in intensive form, if necessary, in the first three, six, or nine weeks of the freshman year with whatever follow-up is necessary coming at intervals throughout the total four years.

The committee asks whether there is any reason why such instruction

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with technical material, where it is in effect a technical writing or a report writing course, it should not be considered as part of the humanistic-social program regardless of whether it is taught by the engineering departments or the English department. This is the kind of follow-up work in communication skills that may be essential, but in the interests of saving time, the committee suggests that such programs be allied closely with the content of some engineering course and incorporated in it.

This does not mean that an upper-level communications course may not have considerable value in both content and method to the humanistic-social sequence. As a matter of fact, it might conceivably furnish the capstone to the program by tying together the technical with the humanistic-social work. A community survey course like the one previously mentioned, and described in more detail in the Appendix, places heavy emphasis on the organization of humanistic-social material for specific purposes, and its effective presentation may call on the student to integrate his scientific and technological knowledge. Projects of this nature may well be an efficient solution to upper-level work in communication.

2. The second recommendation concerns vertical and interdisciplinary integration. When each course must make a new beginning, since the instructor cannot assume that the student has any relevant background for the work, much time must be spent in an elaborate introductory section which, in the planned sequence, can be dispensed with. The fully integrated sequence has an additional advantage in saving time which is not quite so obvious, but is just as real. In separate courses in the several disciplines there is an implicit assumption that subject matter falls naturally into neat blocks of twelve or sixteen weeks, or in multiples thereof. If an instructor has sixteen weeks for a particular body of subject matter, he will take sixteen weeks whether he really needs it or not. If he needs more, he cannot get it. If he needs less, he cannot take it. In an integrated sequence, even without complete reorganization, the essential subject matter may be discussed in seven weeks or seventeen weeks, or whatever number the subject matter makes appropriate. With the group planning which is essential to the integrated sequence and with the super-abundance of content from which to select, there is little danger that the teacher will be permitted to spend more time than his materials justify. Small units of time can thus be saved which will permit more vital subject matter to be included. In composition, too, in those schools where direct instruction in composition is felt to be essential for everyone, the integrated sequence offers a reasonably effective way of saving time. Instruction in the basic skills can be given in intensive form, if necessary, in the first three, six, or nine weeks of the freshman year with whatever follow-up is necessary coming at intervals throughout the total four years.

The committee asks whether there is any reason why such instruction

must always require sixteen or thirty-two weeks? And why is it assumed that it can be completed for all students in this same definite period? The committee suggests that the modular construction of curricula may be an excellent way of promoting inefficiency in the use of time.

3. The third recommendation of the committee concerns adaptation, and this, too, has much to do with time. A considerable part of the work in the humanities and social sciences has to do with interest and attitudes. The engineering student, having set for himself a definite objective, is often impatient with what he may regard as exploratory side trips. The committee holds that an understanding of the different objectives and methods of the humanities and social sciences is an integral part of the training of the professional engineer. Yet our field workers report extreme difficulty on the part of the arts teachers in getting this across, and much time is spent in groping for ways to cope with this problem. One literature department gives as its central objective "making students see what literature is, what it can do for them, what value it has." This, of course, is important, but it can be done most efficiently if the instructor knows where his students are, understands their particular point of view, and directs his teaching to their acknowledged needs and interests. Time will always be required, but the indications are that the time can be used to better effect when the teacher is able to adapt his material to a specific group.

III

In accordance with its charge, the committee thus far has been chiefly concerned with the utilization of time and the improvement of the effectiveness of the humanistic-social program in engineering education. Its arguments have been primarily directed to the people working in these areas. But in any consideration of time, some attention must be paid to the total curricular problem.

This committee has made no study of the use of time in the scientific and technical portions of the engineering curricula. It was outside its province to do so. But it is our firm conviction that what has been said about philosophy, about content, and about method apply as directly to the engineering portions of the curriculum as to the humanistic-social portion. The committee suspects that engineering teachers feel as strongly about the value of their own specialized courses and the traditional treatment of subject matter as do the arts teachers. They may oppose change with the same tenacity and the same emotional intensity. This is why some wag has suggested that reorganizing an academic curriculum is like trying to move a graveyard.

Yet the committee cannot refrain from offering two general suggestions which are in line with its already stated position, though it is aware that these may provoke the same kind of heated disagreement among engineering edu-

cators that the previous sections may evoke from the arts faculties. The recommendations regarding engineering curricular planning are:

1. That engineering educators keep their eyes on the professional training of their students and on preparing them for continuing professional growth, not on their first job. The unrealistic attempt to produce "finished engineers" in four or five years is the principal reason for insisting on the inclusion in the curriculum of many of the highly specialized applied courses of which so many engineers are so fond.
2. That the principles of integration which have been recommended for the humanistic-social stem be also applied more generally to the scientific-technological stem. The relation of the basic sciences, including mathematics, to each other and to the applied sciences should be examined in the same critical spirit the committee has suggested for the humanities and social sciences, and with the same object of increasing the meaning and continuity of the whole program and eliminating unnecessary overlapping and waste of time. This recommendation should be construed neither as an argument against broad training in the basic sciences nor for narrow utilitarianism. The committee recognizes the educational value of the basic sciences. It would like, if anything, the development of a greater breadth of understanding in these fields, but it suspects that this breadth may be achieved, as in the humanities and social sciences, by greater rather than less attention to interrelationships. In the forefront of modern scientific investigation, the discrete nature of the disciplines has been largely lost. Physics, chemistry, mathematics (for example) come together on common ground. Yet the committee found too little reflection of this in the introductory science courses that it observed.

IV

THE question of the five-year curriculum has been raised so many times that the committee feels bound to discuss this possible solution to the time problem, even if only briefly. The obvious theory is that an additional year will provide more time for the broad training of the professional engineer and will solve the time problem for the humanities and social sciences. On both points, the present evidence is inconclusive. Actually, the committee found that the four-year engineering curriculum exists more frequently on paper than in fact. Relatively few engineering schools advertise a five-year program; many more require more than four years, since a majority of their stu-

dents must either make up prerequisites before starting their engineering programs, or must take extra semesters to complete courses failed or coming out of sequence. In one institution the field workers found that only one student in last year's graduating class had actually finished the work in four years.

Many of these institutions are talking about going to five years. Some have already done so. And some others have extended their curricula by entering into various arrangements with liberal arts schools, often on a three-two plan whereby the student takes three years of liberal arts, two of concentrated engineering, and receives degrees from both institutions.

The committee must report that in some of the five-year programs it looked into, the extra time is being used to put in more specialized technical courses rather than more liberal arts courses. And surprisingly enough the same situation obtained in the three-two programs: students preparing in a liberal arts school for ultimate entrance to engineering seem to be so awed at their future prospects that they sometimes take more scientific-technical courses and fewer liberal arts courses in their first three years in the liberal arts school than they would have taken in a similar period in the engineering college itself. The committee feels that neither the five-year program nor the three-two plan will automatically solve the problems of time in engineering education. The basic problem of planning and replanning remains the same.

V

Probably the greatest single practical obstacle to the establishment for all engineering students of a substantial core of study in the humanities and social sciences is the Advanced ROTC program. And this is an obstacle which was not foreseen at the time of the Hammond Report. Nearly all engineering schools today have ROTC programs and our evidence shows that anywhere from 10% to 50% of engineering upperclassmen are enrolled. In a majority of institutions, credit toward graduation, usually 12 semester hours, is allowed for Advanced ROTC. Further, in a majority of institutions, this credit may be substituted for all or a substantial part of the required and elective work in humanistic-social studies. The net effect is that a very high proportion of engineering graduates do not get anything like the amount of study in the humanities and social sciences that the engineering faculties planned and hoped for.

This committee did not undertake an exhaustive study of the ROTC problem since another committee of the Society is doing so. We are, however, gravely concerned about the matter, since it is obvious that the humanistic-social programs are the chief victims of the existing arrangement. It should be noted, however, that the technical programs suffer significantly also and that this is, therefore, a problem of vital interest to all engineering educators.

We hope it is not necessary to say that we believe in the importance, both to the student and to the nation, of the ROTC programs, and we would not, in the present state of the world, wish to see them weakened. The question we raise is about the amount of time and college credit involved, and the relationship of that credit to the humanistic-social program.

First, the essential facts should be made clear. Most land-grant colleges require all able-bodied non-veteran men to take two years of military science and drill, although the land-grant charters compel them only to make such a program available to any students who desire it. The last two years of advanced training, leading to a commission in the Reserves, are optional. Students who take advanced training are paid a small amount and are supplied with uniforms.

There is no uniformity in the matter of granting credit for this work. Practice throughout the country varies from that of granting none at all, to granting as much as 24 semester hours. Where credit is granted, practice ranges from treating it as purely psychological credit (that is, the hours required for graduation are increased by an amount equal to the number of hours of credit granted) to allowing it to be substituted at par value for academic work.

The lack of uniformity in the treatment of ROTC credits is the thing that most struck this committee. Further, we were able to detect no correlation between the credit question and the apparent effectiveness of the military units. In institutions that granted no credit at all, the ROTC units seemed to attract as many students and to have as vigorous and vital a program as those which granted a substantial amount of credit. This latter is an impression rather than a demonstrable fact, but we believe it to be an impression that will be borne out by more careful investigation.

In view of these considerations, we recommend that the Society, through the appropriate committees, move first to establish all the relevant facts; second, to make contact with other educational organizations that may be concerned with the problem; third, in cooperation with representatives of these other organizations, to confer at the national level with the responsible officers of the military services with a view to establishing some kind of uniform policy with regard to the granting of college credit for military courses.

It is the hope of this committee that a policy of granting no credit at all may be established. If, however, it is found that this is not feasible without jeopardizing the efficiency of the ROTC program, the committee feels it would be a considerable gain if practice in the granting of credit could be standardized throughout the country.

One further matter in connection with ROTC needs to be mentioned. Several institutions have begun to substitute ROTC credit for humanistic-social requirements on the ground that the courses offered often closely

parallel courses in the social sciences given by the college faculty. Courses in military history, geography, and leadership training are examples. The committee has examined some of the materials used in these courses, and has found them often of very high quality.

Despite this high quality, we have serious reservations about encouraging this practice. First, the instructors in the military courses are neither permanent nor equally capable of teaching at the college level. Some of them could qualify as members of any college faculty; others could not. Second, the purpose of the military course is to train officers, and classes are seldom conducted in an atmosphere encouraging to the free exchange of ideas, an atmosphere that is indispensable to the attainment of the objectives we have in mind. Finally, the rigid control exercised by military authority over subject matter and examinations is out of the hands of the academic faculty. We doubt the wisdom for any faculty of allowing itself to be maneuvered into a position where it approves degrees earned through taking courses over which it has no effective control.

The committee suggests that as a matter of long-range policy it would be better if the trend were reversed, and the military were asked to substitute, where it is appropriate, academic credit earned in regularly scheduled collegiate courses for some of its requirements. In this way the academic faculty would continue, as it must, to reinforce the important work of the military without involving itself in procedures that might lead to considerable embarrassment.

APPENDICES

Appendix A

Excerpts from the Field Reports

Appendix B

Representative Humanistic-Social Sequences

Appendix C

Courses of Special Interest

Appendix D

Sample Engineering Curricula Incorporating Humanistic-Social Sequences

APPENDIX A

Excerpts from the Field Reports

GENERAL COMMENTS

ONE thing, however, has struck me on my various visits for our project. The colleges seem to welcome the ideas we bring as much as we welcome the ideas we find. X was particularly appreciative. One member of the faculty was later quoted to me as saying: "It was like a cool breeze from the outside." If our small efforts can produce that effect, we have already justified the survey. I hope you will be able to find a place for this point in the final report. It is certainly an argument for improving our system of academic communication.

* * *

But here, as elsewhere, I observed an effect which I think we scarcely contemplated when we began our survey. Our impact upon those we talk with seems greater than their impact on us. I could actually perceive minds beginning to open as we discussed our problems. It seems hard to believe that men might teach undergraduates for years without thinking very much about them, but some ideas which we consider almost platitudes seem to reach many of our interviewees as if they heard them for the first time. Certainly, if we do our work right, no institution can fail to be affected, if only in small ways, by our visits. . . . Whatever the reception of the resulting report, our efforts have not been wasted.

* * *

No steps have yet been taken to provide for a continuation of humanistic-social studies in the first graduate year. This would seem to be desirable, since this selected group of students is the very group most likely to become leaders in society. They are the ones for whom it is most important that they continue to take the broad view of the engineering profession, of society, and of man. In addition to this consideration, however, there is the point that graduate Humanistic-Social work would provide one opportunity for humanistic-social staff members to work with more mature and stimulating minds.

PHILOSOPHY

In talking with staff, it became apparent that more discussion of the objectives of the program with participation of both faculties of Engineering and the relevant teaching departments might result in some changes, both in the program itself and in the individual courses contained in it.

* * *

My impression of the relationship between the School of Engineering at X University and the Liberal Arts Division was that there was much good will but not much intelligence applied to solving the problem of establishing an integration of the humanistic-social stem with the scientific-technological stem. I received the distinct impression that the engineering faculty prescribes so many credits of humanistic-social studies and the liberal arts faculty fills these requirements as a pharmacist fills a prescription. The doctor doesn't consult the pharmacist or vice versa and the patient hasn't the faintest notion of what the medication is or why he is taking it. Stranger still, the doctor doesn't examine the patient or rewrite the prescription either in terms of need or of new pharmaceuticals.

* * *

There is little to say about the history of the scant program in the humanistic-social field for engineers which we found at X. Apparently the Hammond Report had little effect here, but the recent Self-Study Project has begun to show its influence, as previously noted. The spirit of change seems abroad among the engineering faculty, but as much can not be said for the other departments of the College. The apparent reasons for this will be discussed in the Commentary Section, but we may briefly say here that part of the difficulty seems to be lack of mutual understanding, itself due to absence of adequate communication between the engineering faculty and the rest of the College, and even among the engineering departments themselves. There are signs that the general administration of the College is awakening to the problem, but not much yet has been done to improve the situation. But our visit itself may have imparted some impetus; at least that was the impression we gathered in our general conversations, especially with officers of administration.

* * *

This absence of any real plan of liberal study may partly account for what apparently is widespread and strong resistance to the humanistic-social courses that are required. Two or three cooperating departments actually complained of disciplinary problems posed by engineering students in certain courses. In other words, nothing has been done to give these students any

sense of the rationale behind such non-professional work. Maybe this is one of the most important arguments for having an integrated sequence of humanistic-social studies.

* * *

The situation at X is rather easy to describe but very difficult to explain. The facts are that students in engineering are exposed to very few genuinely humanistic or social science courses; that the engineering faculty knows this and is mildly concerned about it; and that only a few men in the arts college care whether engineers receive broader training. The freshman composition courses are skill courses, not humanities. The speech courses are the same, and engineers are segregated in them. There are undoubtedly liberalizing elements in both of these courses, but on the whole they are set up for training rather than for education.

* * *

Both the arts faculty and the engineering faculties thought of the humanities solely in terms of "human relations." The Humanistic-Social stem was considered a useful tool to enable one to "get along with people." This Dale Carnegie version of what constitutes humanistic-social studies means that the program is almost completely devoid of any consideration of philosophical, historical, literary, aesthetic values or content whatsoever, and the Humanistic-Social courses are simply devices by which the student learns a modicum of applied psychology for the handling and treatment of human beings in a factory.

* * *

This engineering college has no clear or even explicit program in the humanities and social sciences. About the only observation that can be made with certainty is that the dean, assistant dean and department heads that we interviewed view the humanities and social studies with suspicion if not distrust. English and speech are accepted for their practical value, as is economics. The course in government would quite probably not be a part of the curriculum if it were not required by state law.

* * *

Because his responsibilities as professional man and as citizen require background and perspective over and above his technical competence, the student of engineering at X devotes about one-fifth of his time to humanistic and social studies. The general aims of these studies are three: understanding of the assumptions of our civilization and their development, capacity for personal satisfaction in literature and in reflective thinking, and competence in the organization and presentation of ideas.

* * *

In practice in the engineering college, each curriculum is heavily loaded with courses in outside but closely related fields, courses which will provide tools for engineers in managerial positions later. This operates to modify the ideal of broadening students and developing them spiritually, into a program of training engineers in additional skills rather than attempting to help them understand their world and become more human in it. Certain social studies lend themselves to this practical purpose, so the "broadening" subjects in the engineering curricula are almost entirely social studies.

* * *

The faculty generally held that the engineers most needed development in reading and thinking about man and his fundamental problems. In the little time available, concentration on the subject matter of the humanities and social sciences (while making use of student's scientific and technological experience in the course of classroom teaching) was deemed the most appropriate approach.

* * *

If engineers continue to place such a naive faith in the significance and effect of "human relations," they will ultimately be disappointed in the humanistic-social offerings. They expect too much of the humanistic-social stem. If they do not get what they over-optimistically expect, they might become so disgusted with the humanistic-social stem that they will throw it out of the curriculum completely at some future date, and engineering education will revert to a pre-Hammond Report status. The humanistic-social courses must guard against promising too much to the engineers and must make them aware of the limitations of the humanities and social sciences in bringing "happiness," "adjustment," or "success" to budding engineers. It would be a frightful disservice to the humanistic-social studies if they are "oversold" to the engineers because the resulting reaction would prevent the humanistic-social studies from accomplishing those things which they are actually capable of doing.

* * *

At X, the faculties seem to feel that human knowledge is too broad and various to be comprehended under one program for general education. Yet they recognize that courses for non-majors cannot be the conventional introductory ones for beginning specialists. Their ideal is to give each student an opportunity to develop some interests outside his own field, and this purpose provides whatever integrating concept exists.

* * *

Among the required courses, economics and psychology are difficult to integrate with history and literature. We observe, in general, that scientific

subjects usually represent a problem in integration. Perhaps greater clarity about the objectives of General Education and their application to engineering students would be of assistance in this connection.

CONTENT

THERE is nothing in a good scientific education that incapacitates a man for citizenship.

* * *

A not negligible number of technical men try on their own to broaden the content of their courses. Perhaps there is even more tendency to do this because of the comparatively weak social science program. Those of us who are interested in an effective over-all program in humanistic-social studies, must guard against breaking down the trend in many of the degree granting departments to present valuable humanistic-social studies information integrated with the technical subjects.

* * *

The program is poorly balanced between the humanities and the social sciences. The only social science is Economics (four hours). No courses in government, political science, sociology, or psychology.

Among the humanities there is no course in history, which is generally regarded as important in non-technical programs for engineers.

Hence there is no balance of any kind. Indeed, our opinion is that though the program may properly be called non-technical, to call it liberal is debatable.

* * *

The second and third criticism would also seem to support the view that one of the abiding dangers of general education is that the wide sweep of generality will become divorced from the patient and systematic examination of concrete fact.

* * *

Wholly apart from the content and level of the psychology course is the question of what is expected of it. The psychologists are trying to teach a complex subject with a specialized vocabulary in the best way they know how. The engineers, however, view psychology as the key to successful human relations, and they tend to look upon it as a sort of college-level Dale Carnegie course, one which will teach the students to be better poker-players than their fellowmen. This bastardized concept of what constitutes psychology and human relations is bound to keep the engineers dissatisfied with

any real offering which attempts to give a psychology course at the college level with real intellectual content.

* * *

It will be noted that X has abandoned the regular freshman composition course. More writing has been incorporated in the first two years to compensate, and it is the feeling of the Humanities group that subject matter and thinking are more important than expression. Others that we interviewed felt that the level of student composition had improved greatly since the work in formal composition was abandoned. It was generally agreed, however, that the X students were superior, though some professors still indicated that they were woefully weak in grammar and spelling when they arrived on campus. All we talked with felt that this was a way in which other schools could benefit by following X's lead. In any technical institution, time is limited for work in the humanities, and it was the consensus that this limited time could not be wasted on a formal review of grammar or on writing themes on "A Day at the Beach." Students once interested in ideas and taught to handle them could be persuaded to be decent in expression.

* * *

The two-year Social Science sequence aims to provide an integration of American history, political science, economics, and sociology. It is taught by instructors from those fields, and the problem approach and case method enable them to use an integrated approach to the topics under discussion. This Social Science integration is not required of engineers at the present time, although it will probably be included among the choices which can be made after the new program is adopted. The professor in charge of the course felt that it would be an excellent course for engineers, although some time would be required to build up the courses and staff to take care of the large number of engineers who might choose to take it.

The chairman of the economics department, however, did not view the Social Science sequence with such enthusiasm. He believed that the student would learn more economics from a one-semester 3-credit hour course in regular economics than he would get from this two-year integrated sequence. Interestingly enough, the chairman of the economics department felt that the economics included in the integrated social science sequence was more highly technical than that in the standard economics course. Yet his criticism was that the integrated course gives only a "smattering" rather than any well-grounded fund of knowledge.

* * *

The integrated courses in literature do not involve faculty members from several disciplines. Rather, the integrative concept is one which involves

a literary approach to non-literary subjects. Thus there is a course which deals with ethical problems in modern literature–how they are treated by the writer and the reader. Then there is a course involving the treatment of social issues at work in American literature, and one which involves the reading of a number of literary masterpieces with particular attention directed to the psychological behavior of the characters. The major emphasis in all these courses seems to be in the ideas, rather than in the form and content of the literature, and to that extent they differ from what many might regard as the traditional literary approach.

The question might arise, not as to whether it is good to teach psychology through the medium of the novel, but whether the English professor knows enough psychology to present a course which has some intellectual validity in the field of psychology. Similarly, is the English professor a qualified sociologist, so that he can give a valid approach to social issues through the medium of the novel? Perhaps the integration is in reverse in these cases; and maybe the psychologist might better give the course which deals with social criticism expressed in literature, and the philosopher give the course involving the treatment of ethical problems in literature. Granted that teaching psychology, philosophy, and sociology through literature is a valid approach to those subjects, the question remains as to whether men trained in these specialties or men trained in English should perform this task. This question does not seem to have been asked by those who present these courses.

* * *

A remarkable degree of integration is achieved with such devices as the concept of comparative cultures, of man struggling against institutions, of historical change, and of continuing problems facing mankind.

* * *

The present procedure is marked by an attempt to integrate by making selective analyses of certain aspects of social activity centered within a *whole* context of human society and culture. No survey is given of the various branches of the social sciences as such. An attempt is made to center attention on developing a holistic understanding of human relations instead of emphasizing descriptive knowledge alone. From this study, it is hoped that the students will learn to use factual information for the activation of critical thinking.

* * *

ARRANGEMENT

THE general pattern at X seems to be thoughtfully worked out and to be generally successful. The four-year required sequence, running through the whole undergraduate curriculum appears to work well. Not much has been

done in integrating this program with the professional work, but this does not appear to be thought necessary. As a matter of fact, the professional faculty seems to feel that the Humanities work should be as different as possible from the technical work; though the obvious high standards of the program are what makes it acceptable.

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As the documentary section will indicate, there has been a constant effort in the Humanities Department at X to present a sequential development so that by the senior year the student has had an educational experience as rewarding in this field, and as searching, as in the scientific-technological stem. There is a considerable leeway in the individual courses for experimentation by the instructor, and the classes we visited show that the students receive the humanities work in the same fresh, experimental way. They enjoy the work and profit considerably from the sequence of courses set before them.

• • •

In those cases where the humanities are introduced in the senior seminar, it is felt that real success is achieved. Engineering students are impressed when an engineer gives a lecture on art or music and shows enthusiasm for the arts. The teachers feel that this is much more effective than bringing in people from the arts to teach their own specialty. Evidence of efficacy can be seen in some real art work (notably sculpture) produced by engineering students under this influence.

• • •

In general, as very successful key courses are evolved, these will probably be required in lieu of some of the present electives. At least one elective will remain (perhaps last term senior year) because of the strong feeling here that the mature student should get a chance to pursue a personal interest and to make an intellectual choice.

• • •

X University appears to have achieved the high goals of the best ideals of engineering education. It turns out educated young men who are trained for engineering, rather than specialists trained in engineering with a limited acquaintaince with arts. X has clearly chosen to teach the spirit, the ideal of the arts, rather than to force on all engineering students regardless of abilities or interests a prefabricated unit of courses labeled humanistic-social.

• • •

Many members of the engineering faculty, and particularly the administrative staff, are truly interested in general education as a means for providing opportunity for students to learn about other important areas of human knowledge and to develop into spiritually conscious individuals who participate in society. They are searching for a way to accomplish this without forcing on a great many students and faculty members a system of values and a selection of fields for study which represent the views of only a few. Whenever a prescribed and limited program is drawn up it must represent a selection according to particular standards, so they face a dilemma.

* * *

Controls over election: Except for ROTC, students have considerable liberty of election. Students are sometimes discouraged from electing courses in the College of Arts and Sciences because upper division students are penalized in lower division courses in the number of credits allowed; engineering students often do not have the prerequisites for upper division liberal arts courses.

* * *

Attempts to integrate the various courses in the humanities program seem to have been few. Apparently the assumption has been made that students will make their own integrations without the faculty helping them by means of studied attempts at integration of course content. Evidences of growing concern about the problem were detected, however. The interest of securing men trained in fields not now represented in the Division is one of the evidences. There is also a logic in the sequence of the required courses. Yet the observer cannot help but feel that integration will come slowly because the tradition of rather specialized courses has been strong and because the tradition of few department meetings precludes the necessary planning.

* * *

The problem of general education for engineers is not essentially different from the problem of general education for any other specialist. However, for a number of reasons it was the College of Engineering on this campus which faced it first. In the first place, the College of Engineering is one of the oldest and the largest of the professional schools. Then too, the crowded curricula made it essential to have particular concern for the optimum utilization of the limited time available. Finally, the importance of years of active interest by the ASEE in this problem is not to be underestimated.

* * *

The engineering student was quite generally regarded as careful and intelligent but overdemanding with respect to precision in the reading and

thinking he performed within the liberal arts program. Apart from difficulties occasioned by his very heavy load in engineering and the subordinate role in which he saw the liberal arts, it was felt that he had trouble working with general ideas and tended to get lost in details. The liberal subject matters interested him but were rather hard for him to "lay his hands on."

* * *

ADMINISTRATION

This institution confirms the impression received elsewhere that probably the all-important factor in the success (or even the setting up) of a progressive humanistic-social program is the interest of the key engineering people, especially the Dean of engineering. It seems to be an axiom that if the Dean really wants it, he can get a worth-while program, whether the school is a university or an engineering college. And if he doesn't, nothing much is likely to happen. Also, here as elsewhere, it seems certain that any really live birth is going to involve labor-pains.

* * *

At the present time there is a very friendly, but unproductive, relationship between the engineering and the arts faculties. They do not get together to discuss problems of common interest and might just as well be on separate campuses as far as any interchange of thought upon matters with which this Humanistic-Social Project is concerned. It appeared that the liberal arts people were ready and willing to co-operate in improving the liberal studies program in the school of engineering if and when they are invited to do so, but it does not seem likely that they will take any initiative.

* * *

To sum up: the development and administration of the present program has been handled democratically (by committee action) but under the very strong personal leadership of the Dean. The compromise seems to be working very well here, and should continue to.

* * *

One fact that stands out is that the underlying philosophy of the general education program and the aims of its four courses have not been adequately explained to either the engineering faculty or the student body. Possibly it is necessary to ram through programs of general education for engineers, (many would deny that it is necessary) but once these programs have been set up it would seem to be extremely important to explain them as fully as

possible. If the Engineering School faculty could have been given a larger role in the creation of the general education program, their attitude toward it undoubtedly would be both more hospitable and better informed. But because they feel it was foisted on them, they tend to take a hostile know-nothing stance toward the general education program.

* * *

The faculties of the two schools have little in common and do not discuss their mutual problems. In general the engineering faculty have little regard for the objectives or capabilities of the arts and economics staffs, and deplore their lack of initiative in coming up with suggestions. The staffs in A and B seem afraid of the engineers. They are on the defensive, and are afraid to discuss their portion of the curriculum because they fear that if it is mentioned, it will be cut out. There is not the mutual regard that would make for a healthy situation.

* * *

Notably absent was any over-all planning committee for the college or even such a committee for the engineering departments alone. Departments are virtually sovereign states at X and maintain very little diplomatic intercourse.

* * *

While this may explain why the engineering faculty can make decisions regarding the arts program for engineers without bothering too much about including the arts faculty in its deliberations, we do not consider this desirable. Despite the fact that the committee on the humanistic-social stem claims that it intends to consult the arts people, we feel that this matter so clearly involves the arts faculty that they should be included in the deliberations and have a real voice rather than merely be consulted at intervals. The problem is intimately concerned with the capabilities and content of the humanistic-social courses, and the humanistic-social faculty should not be excluded from the deliberations.

It is doubtful if the engineers possess adequate knowledge of the function and purposes of the humanistic-social courses to be qualified to pass on their values to engineering students. We would also be opposed to the arts faculty by itself deciding what would be best for engineering students. The most desirable course would obviously be to have a joint committee for the discussion of these curriculum changes. The engineering staff may know what is best for an engineer, but the arts people would also know what is best in the humanities and social sciences. We deplore this attempt on the part of the engineering faculty to make decisions regarding the humanistic-social

stem without incorporating the humanistic-social faculty in deliberations of this nature.

* * *

Careful planning by groups larger than departments may be more difficult because of lack of communication between parts of the campus. Thus, some members of the engineering staff feel that a one-semester rather than a two-semester course in economics would be desirable, since students could then elect a semester of another social science. The head of the economics department felt that such a course should be given. Yet neither side was aware of the feelings of the other.

* * *

Quite notable and commendable was the spirit of cooperation and mutual understanding existing among the deans, engineering faculty and liberal arts teachers, as well as in the ranks of the latter themselves. Even where important differences of opinion existed, the personalities of the men involved managed to keep those differences within the bounds of patient amicability.

* * *

Although the engineering staff is solidly behind their humanistic program, they do not necessarily understand it. They believe that separate departments of English and mathematics are essential for engineering students to receive sympathetic treatment and efficient handling in those areas of instruction. The question might well be raised: on a university campus, is the creation of a separate English or humanities department in the College of Engineering the best *permanent* solution of the problem? The staff of the College of Engineering on this university campus would emphatically answer "Yes."

* * *

The lack of joint planning with the School of Engineering seems to me one of the obvious reasons for the "orphan status" of the staffs of the interdepartmental courses. If they themselves were somehow part of the engineering faculty, their status would be better. If they could work with engineering faculty they might be more aware of the particular needs and interests of their students.

* * *

Our impressions were definitely that the humanities were taken seriously at X by students and faculty, that they were planned and taught effectively, that staff morale and ability were outstanding, and that other engineering schools could profit from studying the X program. It was also clear that lack of funds prevented the department from doing many things they would

like to do (more with music and fine arts, for example) and from having a more attractive physical environment in classrooms and offices.

* * *

It is difficult to see how these programs can be as effective in practice as they are on paper, since teaching loads would seem to make almost impossible the kind of work which an interdepartmental course requires. (Sections of 35 appear to be considered normal, and each instructor carries five, two usually interdepartmental, the rest departmental courses.)

* * *

There is a need here for lighter loads, smaller sections. *Our report should emphasize the fact that "integrated" courses demand a great deal of the instructor and of the student.*

Occasioned in part by large classes, the predominance of the lecture system here at X as elsewhere obstructs the development of the student's understanding and judgment.

* * *

The personal meeting of teachers and students–developed frequently in an informal manner at X–represents an important part of educational experience. In this respect, auxiliary tutorial systems (especially advisable for honor students) and extra-curricular programs in the humanities and social sciences might prove to be of great assistance.

* * *

Again it should be emphasized that staff members who teach in the integrated program are *not* severed from their own departments, and they are definitely not penalized from taking on the extra interest. Quite to the contrary, staff members who are teaching in the integrated courses are achieving academic promotions and salary increases much faster than the average for the college.

* * *

There is a need for giving staff members of integrated courses some kind of autonomy. Apparently if integration is to be carried on on more than one level as it is in this institution, staffs on the separate levels must be made independent of each other. (It was interesting to observe that the directors of the separate humanities and social studies sequences reacted to the combined social-humanities sequence in much the same way that the heads of the

conventional departments did to them and their courses.) *Somehow a man's advancement must be tied in with his work in the integrated sequence.*

• • •

TIME

ADMINISTRATIVE backing for the program and active faculty support are further indicated by the high percentage of time devoted to the humanities and social studies. This institution proves that even in a university, it is possible to devote at least one-fifth of the engineering student's time to non-technical work without his technical training suffering unduly. At least the persons interviewed had no feeling that their students were at any disadvantage when they were seeking employment.

• • •

The particular need of students in engineering (and in other professional programs as well) is for compression. Programs are invariably bulging at the seams with content, and an extremely limited amount of time is available for the humanistic-social studies. Since there is insufficient time for separate introductory courses in each of the many fields of interest, it is essential to provide integrated courses embracing many fields and unconfined by the limits of departmentalized subject areas.

• • •

The department of X and the department of Y cooperate rather well with the engineers, but the department of Z sits *in cathedra* even more obstinately than the A department. It offers a special course for engineers, but apparently despises itself for doing so. I spent a half an hour trying to make the chairman see that a man might benefit from a one-year course in Z even if he had no time for more, but he seemed to persist in his opinion that creatures like us and our engineering students—and indeed all who were not Z majors—belong to the lower orders. I have seldom met so sacerdotal an attitude even among physicians.

• • •

Few of the engineering faculty have any observable concern about the general studies phase of the program although there is no antipathy towards it. Members of the engineering departments are seemingly a bit apprehensive that if too much attention is given to the humanities and social studies the technical competence of the student will suffer. Several times the comment was made that "after all the main thing we are supposed to do is prepare this boy for the technical assignments that he will face after graduation."

• • •

The general direction in which the humanistic-social program is aiming, with integrated general studies continuing throughout the four years but concentrated in the more mature years, is excellent. (This is made possible, in part, by the extent to which the engineering work is pushed into the freshman and sophomore years.) The time devoted to humanistic-social studies is still far too small–of the order of 10 percent of the total. An increase in this percentage could be brought about, it would seem, by the same sort of integrating scholarship in the technical courses which the engineers have insisted upon in the humanistic-social area.

APPENDIX B

Representative Humanistic-Social Sequences

CALIFORNIA INSTITUTE OF TECHNOLOGY

Year	*Term*	*Course Description*	*Units*
I	1,2,3	English: Reading, Writing and Speaking	6
	1,2,3	History of European Civilization	5
II	1,2,3	History of the U. S.	6
	1,2	Economics	6
	3	Human Relations *or* Industrial Organization *or* Business Law	7
III	1,2,3	Introduction to Literature	8
IV	1,2,3	†Public Affairs	2
		Senior Humanities *	9

* Courses chosen by the student from a list including:

Modern Poetry	Modern Drama
Literature of the Bible	American Foreign Relations
Modern Russia	Military History
Modern France	Modern Germany
Political Behavior	Political Parties
The Political Novel	Psychology
Ethics	Logic
Industrial Relations	American Literature
Foreign Area Problems	

3 term courses are required.

† This course is described in detail on page 726.

CARNEGIE INSTITUTE OF TECHNOLOGY

Year	*Term*	*Course Description*	*Semester Hours*
I	Fall	English Composition I	3
		†Historical Development of Western Civilization I	3
	Spring	English Composition II	3
		†Historical Development of Western Civilization II	3
II	Fall	‡Economic Analysis and Contemporary Problems I	3
	Spring	‡Economic Analysis and Contemporary Problems II	3
III	Fall	Psychology of Human Relations	3
	Spring	Introduction to Literature	3
IV	Fall	Electives: normally one in the humanities	3
	Spring	and one in social sciences	3
			30

† This course is described in detail on page 704.
‡ This course is described in detail on page 717.

In his senior year, the student selects a course from each group—one from Group A and one from Group B.

FALL SEMESTER

Group A	*Group B*
Evolution of the Modern Russian State	Problems in Human Relations
Philosophies and Politics I	The Business Enterprise and Government Control
Problems of Philosophy	Economics of Labor
American Social and Intellectual History	Government Finance and Taxation
Modern Drama	Individual and Social Adjustments
American Literature	Social Interactions
Modern Novel	Psychological Foundations of Industrial Behavior
Studies in Poetry I	

SPRING SEMESTER

The Social Background of Art	Economics of Business Finance
The Far East: Contemporary Period	Business Cycles and Economic Stabilization
Modern Germany	Politics and Governmental Process
Philosophies and Politics II	Economics of Money and Banking
History of Science	Individual and Social Adjustments
Comedy in Literature	Psychological Foundations of Industrial Behavior
Classical Literature in Translation	
Studies in Poetry II	
Shakespeare	

CASE INSTITUTE OF TECHNOLOGY

Year	*Term*	*Course Description*	*Semester Hours*
I	Fall	Composition I	3
		†The Background of American Democracy	3
	Spring	Composition II	3
		†The Background of American Democracy	3
II	Fall	‡The Background of Western Civilization I	4
	Spring	‡The Background of Western Civilization II	4
III	Fall	‡The Background of Western Civilization III	4
	Spring	‡The Background of Western Civilization IV	4
IV	Fall	Non-technical elective	3
	Spring	Non-technical elective	3
			34

† This course is described in detail on page 722.
‡ This course is described in detail on page 706.

CITY COLLEGE OF NEW YORK

Year°	*Term*	*Course Description*	*Semester Hours*
I	Fall	English I (composition)	2
		†Social Studies I	3
		Speech I (vocal expression)	1
	Spring	None	
II	Fall	Humanities I	3
		†Social Studies II	3
		Speech II (declamation)	1
	Spring	English II (composition)	2
		Humanities II	3
		†Social Studies III	3
		Speech III (argumentation)	1
III		None	
IV		None	
			22

° Year typically taken; considerable flexibility possible.
† This course is described in detail on page 714.

CLARKSON COLLEGE OF TECHNOLOGY

Year	*Term*	*Course Description*	*Semester Hours*
I	Fall	Communication	3
	Spring	Introduction to Literature	3
II	Fall	†Humanities I	3
	Spring	†Humanities II	3
III	Fall	Speech	2
		Engineering Economy I	3
	Spring	Engineering Economy II	3
		Civilization	3
IV	Fall	Problems of Civilization	3
	Spring	Elective	3
			29

Liberal Studies Electives

American Government
American Literature II
American History Since 1870
Contemporary Fiction
Drama
China and the Far East
U. S. and World Affairs
History of Science I
Psychology
Introduction to Philosophy
Reading Seminar
Russia and Germany in the 20th Century
Sociology and the Family
History of Science II

† This course is described in detail on page 709.

THE COOPER UNION

Year	*Term*	*Course Description*	*Semester Hours*
I	Fall	English I	2
	Spring	English II	2
II	Fall	Public Speaking	2
	Spring	†Civilization I°	3
III	Fall	†Civilization II	2
		Economics I	2
	Spring	†Civilization III	2
		Economics II	2
IV	Fall	†Civilization IV	2
		Elective[1]	2
	Spring	†Civilization V	2
		Elective[1]	2
			25

° Note the five-term sequence in Civilization.

[1] Each senior elects a "humanities elective" each term. The registration for the four electives is roughly equal. The electives offered are:

Contemporary Literature and Art
Economic Geography
Labor-Management Relations
Social Philosophy

† This course is described in detail on page 712.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Year	*Term*	*Course Description*	
I	Fall	†Foundations of Western Civilization	
	Spring	†Foundations of Western Civilization	
II	Fall	Humanities: ‡The U. S.: Men and Issues	Option A
		or	
		§Modern Western Ideas and Values	Option B
	Spring	Humanities: ‡The U. S.: Men and Issues	Option A
		or	
		§Modern Western Ideas and Values	Option B
III & IV	Four semesters of electives, three of which must be in the same field, from:		

History
Modern Languages
Music
Economics
Political Science
Literature
International Relations
Labor Relations
Psychology

Two additional semester subjects may be taken in lieu of science or engineering electives.

† This course is described in detail on page 703.
‡ This course is described in detail on page 724.
§ This course is described in detail on page 725.

MICHIGAN STATE UNIVERSITY

Year	*Quarter*	*Course Description*	*Quarter Hours*
I	1,2,3	Basic 111 (communication skills)	9
	1,2,3	Basic 121 (natural science)	12
II	1,2,3	Basic 231 (social science)	12
III or IV	1,2,3	Basic 241 (humanities) is taken in the junior year by students in the Electrical and Metallurgical Departments; in the senior year by Agricultural, Chemical, Civil, and Mechanical engineers	12
			45

NORTH CAROLINA STATE COLLEGE

Year	*Term*	*Course Description*	*Semester Hours*
I	Fall	Freshman English	3
	Spring	Freshman English	3
		History	3
II	Fall	Economics	3
	Spring	Literature	3
III	Fall	†Contemporary Civilization	3
	Spring	†Contemporary Civilization	3
IV	Fall	‡Contemporary Issues I	3
	Spring	Elective*	3
			27

* Contemporary Issues II
Recent United States History
The American Mind
American Parties and Pressure Groups
Human Relations in Industrial Society
Philosophical Analysis
The Evaluation of Economic Ideas

† This course is described in detail on page 708.
‡ This course is described in detail on page 728.

STANFORD UNIVERSITY

*Year**	*Course Description*	*Quarter Units*
I	English Composition and Literature	9
II	†History of Western Civilization	12
III	Social sciences—Choice of general-education courses in two of the following fields: psychology, economics, sociology, political science, anthropology, geography	10
IV	Humanities—Choice of general-education courses in two of the three areas (1) the Fne Arts, Music, Drama, (2) Philosophy and Religion, (3) Literature	8
IV	Scientific writing	3
		42

* Year typically taken; considerable flexibility possible.
† This course is described in detail on page 702.

UNIVERSITY OF WASHINGTON

Year	*Course Description*	*Quarter Hours*
II	Report Writing	2
	Techniques of Communication	3
III	Humanities–Social Studies	3
	Humanities–Social Studies	3
	Humanities–Social Studies	3
	General Economics	3
III	Modern Reading	Elective
or	Technical Writing	Elective
IV	Business Law	3
IV	Humanities–Social Studies	2
	Humanities–Social Studies	2
	Humanities–Social Studies	1
	Industrial Relations	3

Total quarter hours for various curricula:

A.E.	Ch.E.	C.E.	E.E.	M.E.	Min.E.	Ceramic E.	Metal.E.
22	20	28	26	27	14	25	16

APPENDIX C

Courses of Special Interest

(The following course descriptions have been written by representatives of the institutions involved.)

Course title: HISTORY OF WESTERN CIVILIZATION

Institution: Stanford University

Details: 12 quarter hours (4 units per quarter, 3 quarters).
This is a required course, generally at the freshman level.
This course is required of all Stanford students.
Prerequisites—None.

Purpose:

As part of the general education program at Stanford, this course provides a historical survey of the background and development of the Western tradition.

Course description:

The course starts with prehistoric man, traces the rise of the early civilizations of the Near and Middle East, and then considers Greco-Roman antiquity, the Middle Ages, and the modern period. Social and cultural developments are given equal attention and in the more recent period (since 1500) scientific and technological progress are considered along with the rest of the social and cultural history. Also the growing contacts of the West with the Far East, Russia, and Africa are given attention.

Texts and other materials used:

Burns, E. M., *Western Civilizations, their History and their Culture.*
In addition there are extensive readings in contemporary sources and in special studies. The text-book reading comprises about one-fifth to one-quarter of the total.

Supplementary comment from the institution offering the course:

In order to achieve more efficient and searching analysis, three of the four meetings each week are given over to discussions in sections of 25 each or less. The fourth hour is given to a lecture to the whole group by a specialist in the subject under consideration, either from the History

Department or some other, e.g., Classics, Philosophy, Chemistry, Religion, etc. The discussion method has proved very successful here, because the sections have been kept small.

Further inquiries about this course may be directed to:
Professor William C. Bark
History Department
Stanford University
Stanford, California

Course title: FOUNDATIONS OF WESTERN CIVILIZATION

Institution: Massachusetts Institute of Technology

Details: 3 semester hours (3 class meetings per week for 15 weeks), 2 semesters required.
Required course at the Freshman level.
Designed for science and engineering students.
Prerequisite–None.

Purpose:

This General Education course, focusing on peak periods in the experience of Western Man, aims to sharpen the student's awareness of what it means to be human, of human aspirations and human possibilities, of challenges and responses, at the same time that it provides rigorous training in reading and writing and a basis for later work in the separate scholarly disciplines.

Course description:

Half of the first semester goes to 5th century Athens, the remainder to the Middle Ages. The second semester is concerned with selected facets of early modernity, the 16th and 17th centuries, starting with problems that are mainly political and moving on to the effects of the rise of science on philosophy and political theory.

Texts and other materials used:

There is no text; indeed the use of secondary materials in general is slight. The required reading is mainly in great books, in full or in large chunks. Included are such titles as: *Antigone, Medea, Hippolytus,* Thucydides' *Peloponnesian War,* Plato's *Gorgias;* selections from Aquinas, Dante's *Divine Comedy,* Joinville's *Memoirs of the Crusades;* More's *Utopia* and Roper's *Life of More,* Machiavelli's *The Prince,* Marlowe's *Dr. Faustus,* a Shakespearian play (*Richard II* or *Lear* or *Othello*), some Montaigne, some Calvin, Bradford's *History of the Plymouth Plantation;* Galileo's *Dialogue of the Two World Systems,* Hobbes' *Leviathan* and Locke's *Second Treatise.* Work in other primary and in

secondary or "background" materials is available at the option of individual instructors.

Supplementary comment from the institution offering the course:

The course is taught in discussion sections supplemented with individual conferences on a regular and continuing basis. Except for the required treatment of the common titles, a stated minimum theme writing load, and the need to prepare students to meet a common final examination, instructors have a great deal of freedom in working out their own syntheses, following special lines of interest, etc. Regular staff meetings enable the practitioners of various disciplines, history, literature, philosophy and the like, to educate one another and open up possibilities of different approaches to materials which are in many cases quite removed from the teachers' various specialties. The teaching staff includes full professors as well as young instructors. The reading lists are scrutinized annually and changes are put through according to a consensus of the full group. The reading and writing approach is supplemented by art shows through which students are taken by their instructors. It is hoped that we shall eventually be able to work in music on a comparable basis. One section of qualified students who have expressed the desire to do so does the reading and carries on as much of the discussion as possible in French.

Further inquiries about this course may be directed to:

Professor E. Neal Hartley
Humanities Department
Massachusetts Institute of Technology
Cambridge 39, Mass.

Course title: HISTORICAL DEVELOPMENT OF WESTERN CIVILIZATION I AND II

Institution: Carnegie Institute of Technology

Details: 3 credit hours each semester.

This is a required course at the freshman level.

The course is designed particularly with engineering students in mind —though by now it is considered by its staff as perhaps equally suitable for other freshmen.

Purpose:

(1) to train the students in the historian's basic ways of correcting the selection and ordering of evidence on human affairs subjects, and in bringing questions or assumptions important to them into meaningful relation to such organized evidence.

(2) to improve and deepen their understanding of central institutions and problems in the 20th century world, through historical analysis under the teachers' guidance.

(3) to stimulate their interest in historical literature for itself, and to train them in perceptive reading and in orderly and clear exposition.

Course description:

Runs from 31 B.C. to present, stressing throughout the process of arriving by historical methods at sound judgments on the particular interpretations. First Semester: Roman Empire, early Christians, Germans, and the story of their interpenetration (8 meetings); rise and development (1000–1300) of economic life, church, feudal government, and culture (8 meetings); Renaissance art and politics; church reforms and economics from Luther to Dutch Republic (9 meetings); government and commerce, including Colbert, *Robinson Crusoe,* and Adam Smith (6 meetings); science, Enlightenment, and revolutionary theory and fact, from Galileo to the Terror (11 meetings).

Second Semester: the combination of Napoleon and reaction with industrial advance and reform theories, climaxing in 1848 and Marx (11 meetings); Darwinism, Bismarck, Socialism, imperialism, and power alliances, critique of nationalism, Shaw's *Major Barbara* (11 meetings); science and art since 1880, including Freud, J. H. Poincaré, Einstein, and the Impressionists (5 meetings); First World War and economic results, Communist Russia and Hitler, New Deal and Socialist Britain, World War II and its resultant problems for colonial areas and U.N. (13 meetings).

Texts and other materials used:

Ferguson and Bruun, *Survey of European Civilization,* selections totaling about 40% of reading assigned. (Students buy this and Heffner; other readings are on library reserve.)

Heffner, *Documentary History of the United States,* seven readings used.

Heaton, *Economic History of Europe,* about 100 pages used.

Source readings, selected, from Tacitus to Col. Nasser.

Interpretative analyses, selected, from Gibbon to Walter Millis. (The latter vary in length from two-hour reading to a page; as far as possible they are in the variety of books that might turn up in an average personal library.)

Supplementary comment from the institution offering the course:

The students are divided into sections of 25–30, and class time is spent discussing the problems raised by each day's assignment. Assignments are shaped with care to give training in the skills needed for homework preparation: starting with simple note-taking and map exercises, they build up through more difficult exercises and study questions toward

the goal of successful independent study. The instructors are individually responsible for adjusting the sequence of assignments, and repetitions of training, to fit the progress each section makes.

The readings, though providing over-all survey coverage, are chosen to focus narrative detail, substantial source reading, and conflicting interpretations, at a limited number of precise historical points. Students are expected, in class and in examinations, to reach their own conclusions, and they are helped in many incidental ways to understand that this training in judgment is directly transferable to life and work after graduation.

Further inquiries about this course may be directed to:

Professor P. L. Ward, Head
Department of History
Carnegie Institute of Technology
Pittsburgh 13, Penna.

Course title: THE BACKGROUND OF WESTERN CIVILIZATION I, II, III, AND IV

Institution: Case Institute of Technology

Details: 4 hours per semester. The course runs through the sophomore and junior years.

Required of all sophomore and junior engineering students.

The course is designed particularly for engineering students.

Prerequisite—required courses of the freshman year:
American Democracy I and II and Composition I and II.

Purpose:

(1) To give the student knowledge and understanding of the culture and society in which he lives by acquainting him with the development of that culture and society from its beginnings to the present time; (2) To provide the student with some understanding of the origins and evolution of modern science and technology and to make him aware of the social and cultural impact of scientific and technological developments, thereby making the student think of his future career in other than purely vocational terms; (3) To acquaint the student with Western philosophic, religious, and social thought so that he may work out a satisfactory personal philosophy; to develop, through discussion and study of art, literature, and music, his aesthetic tastes and critical judgment; to broaden and enrich his life as a human being by exposing him to some of the best of human thought and activity in the heritage of Western Civilization.

Course description:

The course uses a chronological framework, starting with the Greeks and continuing to the present day. Within this framework, an attempt is made to integrate all the aspects of a society–political, economic, social, cultural, scientific and technological–into a meaningful pattern. The course is limited to Western Civilization and, while the entire panorama of Western history is covered, there is no attempt to provide equal coverage for all periods. Emphasis is placed on those historical periods which have the greatest relevance to the present; for example, Greek civilization occupies approximately 12 per cent of the course, Roman civilization only about 6 per cent, while fully half the course is devoted to the period from 1789, including one quarter on the period since 1914. Emphasis is placed on developments in science and technology, the social and cultural milieu from which they issued and their impact upon society. The course is not limited to a political and economic survey; fully half the time is devoted to cultural concerns, including religion, art, philosophy, music, and literature.

Texts and other materials used:

Easton, *The Heritage of the Past*
Brace, *The Making of the Modern World*
Knoles and Snyder, *Readings in Western Civilization*
This is supplemented by numerous outside readings from duplicate copies in the library plus a collection of slides, recordings, reproductions of masterpieces of painting and sculpture and other visual aids.

Supplementary comment from the institution offering the course:

This is not a large lecture course. In order to facilitate discussion, the course is given in small sections not exceeding twenty-five men. The staff are trained in various disciplines: historians, specialists in literature, philosophers. While this results in a variety of emphases, the staff, numbering sixteen, use a common syllabus of required work and common final examinations. Advantage is taken of the diversity of staff by changing instructors each semester.

The student is asked to buy a textbook and book of readings. In addition, over one third of the assignments are made in multiple copies of books on reserve in the Case Institute library. Extensive use is also made of audio-visual aids. During the final semester of the course, the student devotes about one quarter of his time to an individual or group research problem in which emphasis is placed on the methods, sources, and problems of such investigation in the humanities and social sciences. Because of the breadth and unusual emphases of this course, the staff has found existing texts and anthologies inadequate and has undertaken to prepare its own.

Further inquiries about this course may be directed to:

Professor Robert L. Shurter, Director
Division of Humanities and Social Studies
Case Institute of Technology
Cleveland 6, Ohio

or

Professor Frederick L. Taft
Executive Officer
Department of Language and Literature
Case Institute of Technology
Cleveland 6, Ohio

Course title: Contemporary Civilization

Institution: North Carolina State College

Details: 3 semester hours each of two semesters; total 6 semester hours.
Required course at junior level.
This course is designed particularly for engineers, but open to others.
Prerequisites—one semester each of European History, Literature, and Economics.

Purpose:

The central purpose is to extend the student's knowledge of the fundamental ideas and forces that continue to shape the modern world, with particular emphasis upon the relationships that exist between science and technology on the one hand, and political, social, philosophic and artistic developments on the other.

Course description:

The medieval world view is examined first as a background to the scientific revolution of the sixteenth and seventeenth centuries; that revolution is studied particularly in the work of Copernicus, Harvey, Galileo, Bacon, Descartes, and Newton. The Enlightenment, the American and French revolutions, and the industrial revolution are dealt with both in contrast to the middle ages and as sources of fundamental ideas and attitudes in contemporary civilization.

The second semester deals with nineteenth and twentieth century thought, paying special attention to new developments in physics, astronomy, and psychology that appear to be changing again man's basic concepts about nature and his relationships to it.

Texts and other materials used:

Readings for Contemporary Civilization (a book of readings specially prepared for this course)
Chaucer, *The Canterbury Tales*

Butterfield, *The Origins of Modern Science*
The Autobiography of Benjamin Franklin
Sullivan, *The Limitations of Science*
Boulding, *The Organizational Revolution*

Supplementary comment from the institution offering the course:

This is an interdisciplinary course designed to show that at the philosophic level all human activities, including science and technology, reflect similar responses to any given set of basic concepts and beliefs. On the practical level, it is hoped that this will help the engineering student understand, first that his professional work is not unrelated to that of others, and second that his own studies, properly understood, provide some bridge to a comprehension of contemporary architecture, music, painting, and literature, as well as ethics and political and social theory.

Further inquiries about this course may be directed to:

Dr. George A. Gullette
Department of Social Studies
North Carolina State College
Raleigh, North Carolina

Course title: HUMANITIES I AND II

Institution: Clarkson College of Technology

Details: 6 semester hours.
This is a required course at the sophomore level.
The course is designed for engineering students.

Purpose:

The purpose of the course is to introduce to the student some highlights of our cultural heritage in literature and the arts, to show how they illuminate human nature, motives, and aspirations, and to give the student some knowledge of the principles, terms, and techniques of the arts. It is hoped the student will develop criteria for sound judgment, and a high sense of human values.

Course description:

The first semester spotlights the literature of Greece, the Bible, and the Renaissance, with an introduction to architecture and sculpture, their problems and techniques. The second semester covers literature from the eighteenth to the twentieth centuries and introduces the student to music and the graphic arts, their techniques and forms. The students write three essays and undertake a creative project in one of the arts. Slides, filmstrips, and films are used along with concurrent exhibitions in the student union. Books listed below give the scope of the course,

but some changes are made each year. To achieve some depth, we spend more time on fewer works.

Text and other materials used:

Homer, *Odyssey* (Rouse translation)
Seven Famous Greek Plays (ML)
Dialogues of Plato (Pocket Book)
The Bible (Rinehart)
Chaucer, *Canterbury Tales* (Coghill trans., Penguin)
Montaigne, *Selections* (Crofts)
Shakespeare, *King Lear* (Kittredge)
Marlowe, *Doctor Faustus* (Crofts)
Milton, *Samson Agonistes and Shorter Poems* (Crofts)
Swift, *Gulliver's Travels*
Rinehart Book of Verse
Arnold, *Four Essays* (Crofts)
Dostoyevsky, *Crime and Punishment*
Shaw, *Arms and the Man*
Steinbeck, *Grapes of Wrath*
Sullivan, *The Limitations of Science* (Mentor)

Supplementary comment from the institution offering the course:

Special features of the course are the combining of literature and the arts, and the creative art project required of the students.

Further inquiries about this course may be directed to:

Professor Donald G. Stillman, Chairman
Department of Liberal Studies
Clarkson College of Technology
Potsdam, New York

Course title: INTRODUCTION TO THE HUMANITIES

Institution: Stevens Institute of Technology

Details: 4 credit hours each semester of the freshman year.
This is a required course at the freshman level.
The course is designed for engineering students.

Purpose:

This course was introduced in 1941 to supplant courses in European History and European Literature formerly given. Although designed particularly for engineering students, since its inception a similar plan has been recommended and adopted for their freshman introductory courses by some of the leading liberal arts colleges as well as by other technical schools.

Course description:

The first term is a study of the foundations of Western Civilization. Instead of trying to present a complete sequence of the development of civilization in the West, we have selected certain specially significant periods and topics in which the patterns of cultural growth can best be observed and analysed in some detail. For five weeks the lectures and reading center on the Periclean Age of Greece–the Fifth Century B.C. Here the characteristics of classical civilization are well illustrated. The next five weeks are concerned with the contrasting structures of medieval Christian society in the 12th and 13th Centuries. The last five weeks of the term deal with the period of the Renaissance where medieval institutions are seen in process of rapid change and the first clear signs of the modern age are apparent. In another sense this period provides a logical conclusion to the term's work, since the Renaissance is in some respects a synthesis of classical and medieval civilization.

The second term of the course deals with the culture of modern Europe. The main emphasis is on the development of modern man and his outlook as shaped by (1) scientific method and the Enlightenment, (2) the great social changes implied in the French and Industrial Revolutions, and (3) Victorian England as an example of the industrial age.

Texts and other materials used:

Reading List–Term I

Herodotus, *Persian Wars* (selections)
Plutarch, *Lycurgus, Solon, Pericles, Alcibiades*
Aeschylus, *Agamemnon*
Sophocles, *Oedipus Rex*
Euripides, *Medea*
Aristophanes, *Lysistrata*
Plato, *Apology of Socrates, Phaedo, Republic* (Books II and III)
Thucydides, *History of the Peloponnesian War* (selections)
Oldenbourg, *The Cornerstone*
Villehardouin, *Memoirs of the Fourth Crusade*
Chaucer, *Canterbury Tales* (selected)
Machiavelli, *The Prince*
Cellini, *Autobiography*
Merejkowski, *Romance of Leonardo Da Vinci*

Reading List–Term II

Shakespeare, *Richard II, Macbeth*
Molière, *Shopkeeper Turned Gentleman*
Voltaire, *Candide*
Pope, *Poems* (selections)

Young, A., *Travels in France* (selections)
France, A., *The Gods are Athirst*
Tolstoy, *War and Peace* (abridged edition)
Marx, K., *Communist Manifesto*
Leo XIII, *De Rerum Novarum*
Maurois, A., *Disraeli*
Ibsen, *Ghosts, Enemy of the People*
Conrad, J., *Heart of Darkness*
Galsworthy, J., *Man of Property*

Supplementary comment from the institution offering the course:

Reading assignments in the course run to 150 or more pages a week. As far as practical the readings are in authors contemporary to the period studied, although we have not thought it wise to be too doctrinaire in this matter. Our aim in choosing the readings has been to present a well-rounded picture of many phases of the period studied. We have preferred famous works where they were relevant but we have not bound ourselves to the dogma of Great Books. In general we have tried to find histories with literary value and literature with historical value.

There are three lectures a week shared equally by three members of the Department. Two of them are concerned with the development of ideas and institutions and general historical background. The third traces the literary influences and manifestations. In the fourth hour the class is met in small sections for discussion. A quiz on the current reading is given in those sections weekly. Every five weeks the class writes an "hour paper" in one of the lecture hours on an assigned topic covering the preceding section of study. The final examination consists of two such topics plus an objective test on the material of the lectures of the whole term.

Further inquiries about this course may be directed to:

Professor John P. Fife
Humanities Department
Stevens Institute of Technology
Hoboken, New Jersey

Course title: CULTURAL HISTORY OF WESTERN CIVILIZATION

Institution: The Cooper Union

Details: Five semesters—11 credit hours.

This is a required course at the sophomore, junior and senior level.

The course is designed particularly with engineering students in mind.

Prerequisite—Freshman English.

Purpose:

The dominant objective in these studies is to lay before the student a recognizable pattern of thought and achievement in the past that will go some way toward giving him a sense of the continuity of his civilization, its principal values and forces.

Course description:

Civilization I—the history, literature, fine art, and philosophic thought of ancient Greece and Rome. Civilization II—major ideas of the Middle Ages and the early Renaissance as seen in the social, political, religious, and artistic ideals of the periods. Civilization III—literature, science, philosophy, social beliefs, and revolutionary ideas from the late Renaissance through the Age of Reason. Civilization IV—major cultural concepts of the nineteenth century with special reference to: the French Revolution, the Industrial Revolution, Romanticism, influence of the biological sciences, rise of modern political theories. Civilization V—American cultural history from the American Revolution to 1900. Study is centered upon Alexis de Tocqueville's *Democracy in America* from which explorations are made into the social, political, economic, literary, and philosophic thought of the period.

Arrangement of the materials for study is made so that literature, history, philosophy, religion, social thought, scientific thought, and the fine arts shall be examined so far as possible in concert, these various branches of human thought and action illuminating one another.

Texts and other materials used:

Setton and Winkler, *Great Problems in European Civilization,* Prentice-Hall, Inc.

Anderson and Warnock, *World in Literature,* Volumes I and II. Scott, Foresman & Co.

Pope, *The Poetry of Pope—A Selection,* Appleton-Century-Crofts.

Swift, *Gulliver's Travels,* Rinehart & Co.

Voltaire, *Candide,* The Penguin Classics.

F. Hegel, *Reason in History,* Liberal Arts Press, Inc.

Alexis de Tocqueville, *Democracy in America,* The World's Classics, Oxford University Press.

Richard W. Leopold and Arthur S. Link, *Problems in American History,* Prentice-Hall, Inc.

In addition to the regular readings and class work in the Civilization courses the following special features are scheduled:

Civilization I—slide lectures on Greek and Roman art one hour each week
—tour of the Cooper Union Museum for the Arts of Decoration

Civilization II—lecture-tour of The Cloisters
—lecture-tour of the Arms and Armor Collection of the Metropolitan Museum of Art

Civilization III—lecture at the Frick Collection on 18th Century painting —lecture, with recordings, on Baroque and 18th Century music
Civilization IV—lecture, with recordings, on 19th Century music —showing of the motion-picture "1848"
Considerable use of slides and recordings is made in regular class sessions to demonstrate how the spatial arts and music, as well as literary works, reveal the dominant ideas of an historical period.

Further inquiries about this course may be directed to:
Professor Weller B. Embler
Department of Humanities
The Cooper Union
Cooper Square
New York 3, N. Y.

Course title: Social Studies I—The Rational and Ethical Foundations of Western Civilization
Social Studies II—Contemporary European Civilization, some Major Problems and Issues
Social Studies III—American Civilization

Institution: The City College of New York

Details: Three credit hours per course for a total of 9 semester hours.
This is a required course begun in the freshman year; many students do not complete the sequence until sometime in their junior year.
The sequence was prepared specifically for engineering students.
Prerequisite—The course does not have any prerequisite. Students, however, cannot take the second term of the sequence without having passed the first term; nor can they take the third term without having satisfactorily completed the work of the second term.

Purpose:
The purposes of the sequence are general and specific.
1. *General:* To enable the engineering student to secure a more effective general education in the social science area of the liberal arts curriculum. The three courses making up the sequence are non-specialized, non-vocational, and inter-disciplinary in the organization of subject matter. They are designed to provide a sound basis for (a) continuing personal development (understanding and behavior), and (b) for the successful assumption of the responsibilities of citizenship.

2. *Specific:*
Social Studies I: This course is concerned with developing a critical understanding and appreciation of some of the major values of Western

Civilization, and a knowledge of their historical background. These values are (a) the rational and scientific traditions (the Greek world is studied for this purpose), and (b) the ethical and religious ideas of Western civilization (the Hebraic and Christian historical experience is examined for this purpose).

Social Studies II: is concerned with some of the major, contemporary problems and issues as they are found in their European setting. The objectives of the course are (a) to describe the historical background of these problems and issues, (b) to examine critically the theory and practice of modern democratic and dictatorial political systems (communism and fascism), and also of capitalist and socialist economies, (c) to clarify the value systems that are represented by these different institutional arrangements, and (d) to study critically the problems and issues created by the conflict between modern national states.

Social Studies III: has as its purpose the examination of some of the salient aspects of contemporary American society. The course aims to develop an understanding and critical appreciation of American political and economic institutions and of some of the major ideals and values held by Americans today in their highly organized, and independent, industrial and urban communities.

Course description:

Social Studies I:

I. Science and the Scientific Method.
II. Basic Concepts: Man in Society.
III. Greece: The Quest for Knowledge of Nature and Man.
IV. The Religious and Ethical Traditions of Judaism and Christianity.

Social Studies II:

I. The Historical Development of Modern Germany, Great Britain, and Russia.
II. The Clash of Economic Systems.
III. Power and Social Mobility–Democracy and the Modern Totalitarian Political Systems.
IV. War and Peace in 20th Century Europe.

Social Studies III:

I. American Political Institutions and Traditions.
II. The American Economy Today.
III. The Changing American Character.

Texts and other materials used:

Social Studies I:

DeBurg, W. G., *Legacy of the Ancient World*
Naftalin, A. and others, *An Introduction to Social Science*
Aristotle, *Ethics* (Book 1), *Politics* (Book 1)
The Bible, major parts of the Old and New Testaments

Russell, B., *The Scientific Outlook* (several chapters)
Huxley, J., *Man in the Modern World* (chapter on social science)
Epictetus, *The Enchiridion*
Lucretius, brief selections (mimeographed)
Epicurus, brief selections (mimeographed)

Social Studies II:

Schapiro, J. S., *The World in Crisis*
Halm, G. N., *Economic Systems*
Oxenfeldt, A. R., *Economic Systems in Action*
Chandler, A. R., *The Clash of Political Ideals*
Pares, B., *Russia*
Maynard, J., *Russia in Flux*
Taylor, A. J., *The Course of German History*
Neumann, F., *Behemoth*
Rowse, A. L., *Spirit of English History*
Williams, A., *Socialist Britain*

Social Studies III:

Commager, H. S., *Living Ideas in America*
Galbraith, J., *American Capitalism*
Riesman, D., *The Lonely Crowd*
de Tocqueville, A., *Democracy in America*
Hamilton, A., Madison, J., Jay, J., *The Federalist Papers*

Supplementary comment from the institution offering the course:

The following special features may be noted with respect to:

1. Course content:

(a) The subject matter of all three courses is interdisciplinary in content and organization.

(b) The interdisciplinary character of the sequence has helped to create a more experimental and fresh approach to teaching. Thus, there has been a continuing re-examination of objectives, methods, and attainments over the years, and there have been several major changes in the curriculum as a result.

(c) This sequence has found itself less bound in the selection of subject matter to be taught by the traditional limits of the regular disciplines. The staff has therefore been able to concentrate more heavily on what it considers the most important subjects.

(d) These courses have made it possible to give attention to problems, issues, and values, and to stress more regularly the need for critical thinking about social experience.

2. Administration:

(a) Courses are 'run' by staff members who draw up the syllabi, choose the readings, and prepare common examinations.

(b) Teachers in the sequence are full-time members of social science departments in the Liberal Arts College. These instructors teach part of their program in the Social Studies sequence; the remainder of their teaching is done in their 'home' departments.

(c) The responsibility for administering the Social Studies Sequence is assigned by the School of Technology to the Dean of the College of Liberal Arts. The Dean, in turn, appoints a coordinator who is responsible for the actual administration of the program. This person is a regular member of an academic department (at present he is an associate professor in the History Department) and he offers courses in his own department as well as in the Social Studies Sequence.

(d) The coordinator cooperates with the chairmen of the several social science departments in selecting staff members who are competent and willing to teach in the program.

(e) At present teachers in the following academic departments are represented in the Social Studies staff: Anthropology and Sociology, Economics, Government, Philosophy, and History.

Further inquiries about this course may be directed to:

Professor Oscar Zeichner
Department of History
The City College
139th Street and Convent Avenue
New York 31, N. Y.

Course title: ECONOMIC ANALYSIS AND CONTEMPORARY PROBLEMS I AND II

Institution: Carnegie Institute of Technology

Details: 3 hours (9 units) per semester; course runs two semesters.
This is a required course at the sophomore level.
Prerequisite: Historical Development of Western Civilization I and II.
The course is specially designed for engineering students though it could be used by other students without major change.

Purpose:

The primary objectives of the course are:

(1) to stimulate an awareness of, and a continuing interest in, the broad range of economic problems in modern society. Such problems should be seen in the light of their historical background and as existing in a broad current context extending beyond the traditionally conceived boundaries of formal economics.

(2) to place special emphasis on good methods in thinking about social problems in general and economic problems in particular. This objective involves specific attention to the process of orderly problem solving, including careful attention to the processes of logical consistency and to the bases for belief. In the problem areas the focus is on the question: What, all things considered, should be done about any particular social situation (including, of course, situations where complete information is missing)?

(3) to give the student a firm grasp of the few basic principles and operating concepts which he must have in order to think intelligently about economic problems.

(4) to reemphasize and give the student further experience in applying the methods of historical analysis as they were developed in the course "Historical Development of Western Civilization." This includes the importance of seeing present situations in a proper time perspective; emphasis on the fact that the most important problems lie across economics and other social sciences; and the necessity for careful evaluation of evidence.

(5) to provide a good deal of information on modern socio-economic institutions and processes (such as the business corporation and the influence of pressure groups on legislation) primarily as part of the statement and analysis of major problems throughout the course.

(6) to help train the student in thorough, exact reading and in careful concise written and oral expression.

Course description:

The first section of the course is a short examination of the basic elements in the process of handling decision-choice problems—a brief analysis of the problems of straight thinking on social (public policy) problems.

The course then proceeds to the examination of a variety of socio-economic problems, including the problems of agriculture, monopoly, unemployment and inflation, on which the citizen needs to make public policy choices. In each broad problem, an attempt is made to develop the economic tools needed for the analysis; the situation's historical and institutional background, and an awareness of the broader aspects of the problem which will help students handle it in the light of their own social objectives.

The course will be divided into the following major sections:

1. Introduction (about 3 class sessions)
2. Methodology (about 9 class sessions)
3. The business firm (about 5 class sessions)
4. Competitive market analysis (about 12 class sessions)
5. Non-competitive market structures (about 10 class sessions)
6. Measures of national income (about 5 class sessions)

7. The monetary system (about 6 class sessions)
8. The analysis of macro-economic problems (about 14 class sessions)
9. International trade (about 4 class sessions)
10. Income distribution and labor unions (about 7 class sessions)
11. Comparative economic systems (about 3 class sessions)

Texts and other materials used:

The basic text is G. L. Bach, *Economics* (Prentice-Hall, 1954). This is supplemented by a variety of other materials, especially Beardsley, *Practical Logic,* in the introductory section; by Williamson, *Growth of the American Economy* for historical background at a number of points; and by a substantial number of shorter pieces (mimeographed by permission) as indicated in the syllabus. The basic text is used for the framework and central analytical tools; other materials are primarily in connection with the major problems around which much of the teaching is done.

Supplementary comment from the institution offering the course:

The course is primarily planned and supervised by the Economics Department, but all work is done in close cooperation with the History Department, and the course is staffed by about two-thirds economists and one-third historians.

Further inquiries about this course may be directed to:

Dean Glen U. Cleeton
Division of Humanities and Social Studies
Carnegie Institute of Technology
Pittsburgh 13, Penna.

Course title: SOCIAL-HUMANITIES SEQUENCE

Institution: The City College of New York

Details: First semester–7 hours per week (6 credits)
Second semester–4 hours per week (3 credits)
Third semester–3 hours per week (3 credits)
Fourth semester–3 hours per week (3 credits)
This is a required course at the Freshman and Sophomore level.
The course is offered only to engineering students at present, but it was designed on a much broader basis.
Prerequisite–None, except that each course in the sequence must follow in numercial order.

Purpose:

The social-humanities sequence is a series of courses, interdisciplinary in character, designed to bring the work of the social studies and the

humanities areas together to form a single unit. Certain cultures or periods like 5th Century Athens, 7th Century Palestine (B.C.), Reformation, Humanism and Renaissance, or "America in the Twenties," are intensively studied as a whole. Great books of the past and present, from Plato to Faulkner, are used to help the student understand the background, the spirit, the ideas and values of the period. From the contradictory values of western culture, and the understanding of democracy as a wholeness, the student is helped to derive for himself a system of values which would provide those personal and social satisfactions which the liberal tradition used to call "the good life." By encouraging the student to engage in class discussions and panels on specific recurring problems of mankind, the student is helped to develop thinking habits and reading habits which would enable him to face and meet the issues of today and tomorrow in a rapidly changing world.

Course description:

I. *Foundations of Western Culture:* (a) *Patterns of Culture* and four novels are taken up (*Contemporary Culture unit*); (b) Fifth Century B.C. Athens; (c) 7th Century B.C. Palestine; (d) 1st Century A.D. Palestine.

II. *Modern European Culture:* (a) Humanism; (b) Reformation and Renaissance; (c) The Age of Reason; (d) Industrialism, and Economic theories; (d) Democracy.

III. (a) *American Culture* and problems in American Civilization such as: Amherst pamphlets on *American Revolution, The Signing of the Constitution* and *Andrew Carnegie and the Gospel of Wealth;* (b) Romantic poetry and social poetry; (c) Totalitarianism.

IV. *Cultural Values:* Leading currents in philosophy, psychology, history, sociology are taken up via first-rate works of literature in order to help the student find a philosophy of life for himself by finding his values for living from amid the contradictory values of contemporary western culture.

Texts and other materials used:

I. (a) Benedict, Ruth, *Patterns of Culture*
Fitzgerald, *The Great Gatsby*
Dos Passos, *Big Money*
Huxley, *Brave New World*
Orwell, *1984*

(b) *Agamemnon*
Oedipus Rex
Medea
Thucydides, *Peloponnesian Wars*

Plato, *Crito, Apology, Phaedo, Symposium, Republic,* in part.
Old Testament, Prophets, Job, etc.
New Testament, Gospels, as arranged in *A Bible for the Humanities* by Thirwell and Waldhorn.

II. Brinton, *The Shaping of the Modern Mind*
Tawney, *Religion and the Rise of Capitalism*
Marlowe, *Dr. Faustus*
Othello
Rousseau, Burke
Paine (Minnesota Humanities Pamphlets)
Adam Smith to Karl Marx (Minnesota Humanities readings).

III. Untermeyer, *A Treasure of Living Poetry*
Pares, *Russia*
Commager, *America in Perspective*
Problems in American Civilization, Amherst Series: The American Revolution, Signing the Constitution, The Gospel of Wealth

IV. Turgenev, *Fathers and Sons*
Faulkner, *Intruder in the Dust*
Melville, *Moby Dick*
Otto, *Science and the Moral Life*
The Toynbee Thesis; Human Destiny (Lecomte du Nouy)

Audio-visual materials, film strips, records, TV films are also used.

Supplementary comment from the institution offering the course:

1. The teachers in the course meet every other week to discuss progress and problems and are given the opportunity to suggest improvements which are carried out. This gives the men a feeling that they are engaged in self-education and creative teaching.
2. Audio-Visual Aids are correlated with class room work. This semester the lecture hour in Course I (the 7th hour) heard lectures, most of them given by outsiders, on (a) Integration and Meaningfulness in studying cultures and works of literature; (b) Film *The Roosevelt Story;* (c) The world of Thomas Wolfe; (d) The world of Faulkner; (e) Televised film *The Great Gatsby;* (f) Homeric Culture; (g) Athens and Sparta; (h) 'Omnibus Program' televised and reproduced on film by the courtesy of the Ford Foundation; (i) Antigone; (j) Greek Science; (k) Aristotelian philosophy, etc.
3. The course is dynamic and changing. The total philosophy remains the same but the items are tried and tested and retained only where the books used are effective.
4. The last lecture period in Course I is a *student program* in which six students and one student moderator discuss the pros and cons of

material taken up during the semester. Issues such as "The Greeks have a sounder conception of the Universe than the Hebrews,' 'Democracy's Inevitable Weaknesses are Insurmountable' or 'Culture should seek security, peace and stability instead of adventure, conflict and variety,' are debated in this forum.

5. Students are trained to get up in front of the room to take parts in plays, to represent historic personages, to engage in debate or to deliver a short paper on meaningful sections of the readings.
6. The teachers are encouraged to teach all the courses in the sequence so that the total philosophy and purpose of the sequence as well as the subject matter learned by the student is clearly before him as he enters the room and begins to teach a specific course in the sequence. Correlation is well-achieved.

Further inquiries about this course may be directed to:

Professor Louis F. Sas
Department of Romance Languages
The City College
139th Street and Convent Avenue
New York 31, N. Y.

Course title: THE BACKGROUND OF AMERICAN DEMOCRACY I AND II

Institution: Case Institute of Technology

Details: 3 hours per semester.
Required for Freshman year.
Particularly designed for engineering and science students.

Purpose:

To help create in the student a keen sense of his responsibility as an individual, as an American, and as a member of a free society. To introduce him to the social sciences as part of our sequence of courses in the Humanities and Social Sciences and to promote an understanding of contemporary social, economic, and political problems.

Course description:

As it now stands, this course is composed of three general sections: ten weeks of social psychology, ten weeks of institutional economics, and ten weeks of American government. The first section presents some of the principles and methods of resolving conflicts among individuals and groups in America. The second describes the operation of our economic institutions and the relationship between our economy and our society. The third section is designed to supplement the student's

knowledge of the structure and process of his national government and to clarify the ideas of human behavior upon which our political system is based.

Texts and other materials used:

Berrien, F. K., *Comments and Cases on Human Relations,* Harper and Brothers, 1951.

Baker, T. W., *Our Economic System* (in multilith). Part of a planned text.

Burns, J. M. and Peltason, J. W., *Government by the People,* 2nd ed., Prentice-Hall, 1954.

Cases (in multilith) written by the staff.

Supplementary comment from the institution offering the course:

The parts of the course are held together by a definite focal point, contemporary America, and a procedure of moving from the individual to groups, from the simple to the complex, and from the concrete to abstractions. This process, we think, gives our students the means and techniques for studying and being interested in other cultures, contemporary and past.

Because we believe democracy places a high premium on decision-making by the individual citizen, we give our students, as much as we can, the opportunity to make their own decisions in action-demanding cases, to do their own thinking, and to change their attitudes. This procedure may be an answer to these questions:

1. How can we change hostile attitudes toward the study of man and society?
2. How can we transfer student problem-solving interest from the physical to the human areas?
3. How can we raise questions of individual and social values in an interesting manner?

Further inquiries about this course may be directed to:

Professor Robert L. Shurter, Director
Division of Humanities and Social Studies
Case Institute of Technology
Cleveland 6, Ohio

or

Professor Thomas E. Baker
Executive Officer
Department of Social Studies
Case Institute of Technology
Cleveland 6, Ohio

Course title: THE U. S.: MEN AND ISSUES

Institution: Massachusetts Institute of Technology

Details: 3 semester hours (2 class meetings per week for 15 weeks), 2 semesters required.

This is one of two humanities courses between which all sophomores must choose.

Designed for engineering students.

Prerequisite—the required Freshman Humanities Course.

Purpose:

The underlying purpose of the course is, first, to give the student a deeper understanding of his values and attitudes and his limitations in understanding human and social situations; secondly, to give him an appreciation of the nature of the democratic process; thirdly, to provide him with essential information about the operational values and institutions of the society in which he will live and work; and, finally, to indicate how these values, institutions and his whole way of life grew out of the American experience over time.

Course description:

The course does this by focusing on four major issues in the American experience: the making of the Constitution, the coming of the Civil War, the formulation of economic policy in an industrial democracy (considering first the regulation of the corporation and then the regulation of the over-all economy) and the formulation of foreign policy in a democratic world power (concentrating on the making of policy since 1939).

Texts and other materials used:

There is no text. Where possible the writings of the policy makers and other men involved in the issues are read. Novels and poetry are used to illustrate the ideological and cultural situation in which the policy makers worked and to help make clear the nature of the rationales and justifications of the positions they took on the basic issues.

Further inquiries about this course may be directed to:

Professor Alfred D. Chandler, Jr.
Humanities Department
Massachusetts Institute of Technology
Cambridge 39, Mass.

Course title: MODERN WESTERN IDEAS AND VALUES

Institution: Massachusetts Institute of Technology

Details: 3 semester hours (3 classes per week for 15 weeks), 2 semesters required.
This is one of two humanities courses between which all sophomores must choose.
The course is designed for all Massachusetts Institute of Technology students.
Prerequisite–the Freshman Humanities Course.

Purpose:
To inform the student about his ideological heritage and to *involve* him with it by stimulating him to discover and assess not only the significant intellectual contributions of the recent past but his own values as well.

Course description:
First Semester: Study of representative documents of three historical periods, the Enlightenment, Romanticism and Victorianism. Emphasis is placed on long reading assignments in primary sources. The writings selected cover a wide area of human endeavor including political thought, ethics, epistemology, natural science and belles lettres. The course is built around a required reading list common to all sections and a list of optional readings from which the individual instructor can select according to his own and his students' interests.
Second Semester: The same general approach obtains as for the first semester, and the course is organized around such topics as the Revolt from Victorianism, Twentieth Century Totalitarianism, Bases for Values in the Pluralist West.

Texts and other materials used:
Paper back and other inexpensive editions of famous originals are used as much as possible. A sample list follows for the First Semester:

Paine, *Rights of Man*
Hume, *Enquiry Concerning Human Understanding*
Voltaire, *Candide*
Emerson, *Essays*
Stendhal, *Scarlet and Black*
Darwin, *Origin of Species*
Mill, *On Liberty*

Supplementary comment from the institution offering the course:
Sections are limited to approximately twenty-five students so that the course may properly be built around the discussion method. A major purpose

of the course is to improve the students' writing. Consequently, considerable emphasis is placed on student essays written outside of class. These essays written on significant problems related to course content are the subject for personal conferences between student and instructor.

Further inquiries about this course may be directed to:

Professor Irving H. Bartlett
Humanities Department
Massachusetts Institute of Technology
Cambridge 39, Mass.

Course title: PUBLIC AFFAIRS

Institution: California Institute of Technology

Details: One hour class and one hour outside reading for the full academic year.
Required course for all seniors.
Course is designed for all students
Prerequisite—None

Purpose:

To encourage the students to keep themselves informed about problems at the national and international level and to assist them in their efforts to appreciate the point of view of other sectional or national groups.

Course description:

We discuss in class a variety of selected topics which are of concern to the national government of this country. For example, in this term we have been discussing in class the political and economic structure of Soviet Russia. Next term we shall be looking at such countries as China, Guatemala, Turkey and Great Britain. We also take up from time to time such problems as the question of civil liberties or of natural resources.

Texts and other materials used:

The students read the News of the Week section of the *New York Times.*

Supplementary comment from the institution offering the course:

We attempt to supplement the work of the class by encouraging the students to make use of our very effective Public Affairs Room where there are exhibits on problems of topical concern and extensive materials on national and international affairs.

The instruction in the course is undertaken by various members of the faculty and by visiting lecturers of whom the most important are four men who come to us every year from the American Universities Field Staff.

Further inquiries about this course may be directed to:
Dr. David C. Elliot
Humanities Division
California Institute of Technology
Pasadena 4, California

Course title: CONTEMPORARY PROBLEMS

Institution: University of Cincinnati

Details: 3 credit hours for each seven week term.
Required course for senior engineers.
Designed particularly for engineering students.
Prerequisite–None

Purpose:

Within the last half-century the United States has become involved in two world wars. Neither of these wars began in the United States nor were they started by this country; and yet eventually the United States was drawn into both of these conflicts in defense of its national security. In each of these wars the Americans hoped that when they were over there would be a happier and better world in which all peoples would govern themselves and there would be perpetual peace and universal justice. Yet after each war the American people began, in time, to realize that their hopes had not been realized. But as a result of these wars the American people today, more than ever before, know that whatever happens in any part of the world is a matter of vital concern to them personally; and they also know, more than ever before, that the greatest aid in trying to understand the complex cross-currents of present day world politics is a knowledge of the historical background of these issues and of the men and forces which have created these problems. It is with this thought in mind that this course has been organized. It is designed to awaken in the student an interest in current problems and give him an intelligent understanding of these questions in the light of their historical background.

Course description:

The origins of World War I and of World War II are traced in order to explain the forces which brought on these conflicts; why the problems of peacemaking after each of these wars was so difficult and why no durable peace was obtained; and what have been the most significant political, economic, and social trends in Europe and Asia since the end of World War II and what problems they have created for the United States. While the core of the course traces the trends in Europe and

in Asia in the last half-century, the increasing involvement of the United States in world affairs, inevitably makes the course one in global history.

Texts and other materials used:

Walter C. Langsam, *The World Since 1919* (Seventh Edition, 1954).
New York Times Sunday Edition

Supplementary comment from the institution offering the course:

A special feature of the course is a short quiz every week on assigned material contained in the News of the Week in Review section of the Sunday edition of the *New York Times.* These quizzes are in addition to the regular hour quizzes based on material in the text (Langsam) and the lectures.

Further inquiries about this course may be addressed to:

Professor Reginald C. McGrane
Head, Department of History
University of Cincinnati
Cincinnati 21, Ohio

Course title: CONTEMPORARY ISSUES

Institution: North Carolina State College

Details: 3 semester hours each of two semesters; total 6 semester hours.
This is a required course for the first semester—elective for the second—at the senior level.
The course is particularly designed as a capstone to the humanistic-social sequence for engineers, but is open to others.
Prerequisites—All preceding courses in the humanistic-social sequence.

Purpose:

The purpose is to provide some bridge between the classroom and the world of public affairs, to help the student utilize his total education in the analysis of contemporary problems, and to stimulate a continuing interest in keeping informed about the major issues that confront our society.

Course description:

The large problem of redefining individual freedom in a twentieth century context provides the intellectual framework for the year's study. In general, the first semester centers attention on domestic problems, the second on international affairs. The specific issues dealt with may vary from year to year. Currently, the first semester considers civil liberties, with the Oppenheimer case as a concrete example; private versus public enterprise; and segregation in the schools. The second semester

studies the East-West split in its ideological, political, economic, military and cultural aspects.

Texts and other materials used:

The New York Times, Sunday Edition
Today's Isms, Ebenstein
Selected issues of *Current History*
Documentary materials for each problem
The Grapes of Wrath and similar relevant novels of social purpose.

Supplementary comment from the institution offering the course:

There is one lecture and two section meetings each week. Section size is held below twenty to facilitate discussion. Every effort is made to treat each problem in its total complexity, that is, in its moral, its economic its social, and its practical aspects. Controversial issues are not avoided, but they are dealt with as objectively as possible. The student is encouraged at every turn to think problems through for himself, though much is made of the fact that he cannot do so without a command of the relevant evidence. This is a use of the problems course as a culmination, rather than an introduction to, the study of the humanities and social sciences.

The device of multiple lecturers has been used to good advantage in sharpening the issues involved in any problem. Two, three, and even four staff members may in a given lecture hour present the conflicting arguments surrounding any issue.

Further inquiries about this course may be directed to:

Dr. George A. Gullette
Department of Social Studies
North Carolina State College
Raleigh, North Carolina

Course title: THE USES OF LANGUAGE

Institution: Rensselaer Polytechnic Institute

Details: Three credit hours for 16-week semester (48 class meetings)
Required freshman English course
Designed for all college freshman
Prerequisite—None

Purpose:

The course is an intensive workout, both theoretical and analytical, with language in three of its basic uses: to inform, to "create," and to persuade. The aim is *to extend the student's critical control over language,* both his own and that directed at him.

The course requires the student to both broaden and sharpen his *understanding* of language—of its symbolic nature; of its various uses; of how it performs its different jobs; and of the ways in which the reader must "shift gears" as language changes its function. Second, the student develops some *skill* in differentiating uses, in critically analyzing each, and in writing at least informatively.

Course description:

The first few meetings are on language in general—its nature, its main uses, and its relation to other familiar modes of communication and expression. Some background reading in the theory of language is required, both here and later.

The three sections of the main course follow, each devoted to detailed study of one use of language. About five weeks are spent on *informative* language (in news and other reports, historical and philosophical pieces, and miscellaneous articles and essays); six weeks are given to "*creative*" language (in poems, stories, plays, a novelette); and three weeks go to the ways of persuasive language (in pseudo-reports, editorials, advertisements, and other propaganda).

In each section, two basic problems are emphasized: *how words themselves work,* when put to this purpose; and *how they are organized* into formal structures.

The last few meetings are used for review and for introductory discussion of certain more general problems, such as the different sorts of "meaning" language can have, the value of each, and how each should be judged.

Texts and other materials used:

So far, no really adequate text for the theoretical part of the course exists, though one is in preparation. At present, some chapters in Hayakawa's *Language in Thought and Action* and in Hummel and Huntress's *The Analysis of Propaganda* are somewhat useful. The theory of "creative" language is presented by the instructor. Specimens for critical analysis are drawn from various media—newspapers, magazines, paperbacks, and an anthology of assorted literature. In discussing imaginative literature, use is also made of paintings and recorded music. Considerable writing is required.

Supplementary comment from the institution offering the course:

This experimental course (offered since 1953) is apparently unique in concentrating on *language itself*—its symbolic nature, its relation to nonverbal modes, its various functions, and its shifting strategy and tactics.

Thus the emphasis is not on the elements of composition (as in most freshman writing courses) though the course probably improves student

writing; nor on literary elements and types (as in many introductions to literature); nor on forms of verbal activity (the reading, writing, speaking, and listening of most 'communication' courses). Yet neither is the course one in semantics, literary criticism, nor linguistics, though some of the principles of all three are introduced.

Especially important in this course is the constant interrelating of language and such other common symbolic modes as mathematics, graphics, music, and the visual arts.

Further inquiries about this course may be directed to:

Dr. Sterling P. Olmsted, Head
Department of Language and Literature
Rensselaer Polytechnic Institute
Troy, N. Y.

Course title: COMMUNITY SURVEYS

Institution: Columbia University

Details: Lectures, conferences and field trips at Camp Columbia, the summer school of engineering. Three weeks, 8:00 a.m.–10:00 p.m., 5 days weekly, 3 points credit.

Required of electrical, industrial, mechanical, metallurgical and mineral engineering students the summer prior to Junior year.

Particularly designed for engineering students but open to others. Has been of interest to students in geography, town planning, education, anthropology, sociology, government, and economics.

Prerequisite–2 years of college

Purpose:

To give students an opportunity to examine the life of a small industrial community–to provide an understanding of the impact of technology upon the social, political and economic life of a community and to emphasize the civic responsibilities of the professional man.

Course description:

Intensive field study of a typical small or medium-sized industrial community and the preparation of reports on industrial activities, public utility operations and community services. Evening conferences and round-table discussions are held with executives, labor representatives and civic leaders.

Texts and other materials used:

No regular text is available. However, much use is made of State Development Commission reports, annual Town Reports, Federal Census

reports, motion pictures, corporation reports, etc. A reference library of several hundred volumes is maintained at camp.

Supplementary comment from the institution offering the course:

The staff is drawn from University Departments of Economics, Government, Sociology, Geography, etc., as well as Industrial, Electrical and Mechanical Engineering.

The work of the students and staff brings to the community a new awareness of the problems of the community as seen by the disinterested observer.

Further inquiries about this course may be directed to:

Professor W. W. Waite
Executive Officer, Department of Industrial Engineering and Management
School of Engineering
Columbia University, New York 27, N. Y.

Course title: APPLIED EXPERIMENTAL PSYCHOLOGY

Institution: Tufts University

Details: 3 credits per semester for two semesters.
This is an elective course at the intermediate level.
The course is designed with the engineering student in mind. It is however, open to Liberal Arts students also.
Prerequisite—first semester—none
second semester—either the first semester or experimental psychology.

Purpose:

To indicate the limits of human physiological and psychological capacities which demands made by machines on their human operators must not exceed.

Course description:

The first term emphasizes man's receptor and motor capabilities. The second term considers the human factor in relation to equipment design, the working environment, and work methods. In typical man-machine systems the display, control and display-control relationships are studied to determine general principles which may be applied to the design of new equipment.

Texts and other materials used:

Chapanis, Garner and Morgan, *Applied Experimental Psychology.*
Outside readings are taken from introductory psychology and physiology texts and from research reports which have bearing on the various topics.

Further inquiries about this course may be directed to:

Professor Philip B. Sampson
Department of Psychology
Tufts University
Medford 55, Massachusetts

Course title: BIOLOGICAL SCIENCES

Institution: Washington State College

Details: 3 hours per semester.
Elective course–freshman to senior level.
Designed for all students.
Prerequisite–None

Purpose:

A study of the attributes of living things, and the unifying concepts and methods of the biological sciences (Bacteriology, Botany, Zoology and their technologies).

Course description:

I. The Nature of Living Things
   A. The structure of living things
      Survey and classification; organs, tissues, cell theory, protoplasmic theory
   B. The activities of living things
      Synthesis, digestion, respiration, growth, reproduction, irritability and adaptation
II. The Whole Animal: Man
   The embryology, histology, and functioning of the vertebrate organism, using Man as the primary example.
   Includes digestive system, circulatory, respiratory, excretory, nervous and endocrine systems.
III. The Whole Plant: The Apple Tree
   The structure, (sporophyte and gametophyte) of a vascular plant, using the Apple Tree as the primary example. The functions; water relations, mineral nutrition, photosynthesis, translocation and storage, reproduction are studied in detail.
IV. Summary: Living things and the World About Them, through the Ages.

Texts and other materials used:

Weisz, Paul B., *Biology,* McGraw-Hill Book Co., Inc., N. Y., 1954.
Hardin, G. A., *Biology, its Human Implications,* W. H. Freeman & Co., San Francisco, Calif., 1953.

Supplementary comment from the institution offering the course:

Our method of teaching is to present the factual material to the class as a whole in lectures, and through assigned readings, and to attempt to have each student integrate the facts into useful biological concepts through planned questioning periods, in which a maximum of twenty students participate ('Dialogues').

Further inquiries about this course may be directed to:

Associate Dean
Division of Natural Sciences
Washington State College
Pullman, Washington

APPENDIX D

Sample Engineering Curricula Incorporating Humanistic-Social Sequences

(Note: The purpose of this section is to illustrate how a substantial humanistic-social program can be incorporated into engineering curricula of various types. It is hoped that these examples will prove helpful to engineering educators who want to encourage liberal studies, but do not see how the necessary time for them can be found.)

CASE INSTITUTE OF TECHNOLOGY — CHEMICAL ENGINEERING

FRESHMAN YEAR

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
Anal. Geometry–Calculus	4	Calculus I	4
Physics I	3	Physics II	3
Chemistry I	4	Chemistry II	4
Composition I	3	*Composition II*	3
Graphics I	2	Graphics II	2
Background of Democracy I	3	*Background of Democracy II*	3
Physical Education	0	Physical Education	0
	19		19

SOPHOMORE YEAR

Western Civilization I	4	*Western Civilization II*	4
Calculus II	3	Differential Equations	3
Physics III	3	Physics IV	3
Physics Lab. I	1	Physics Lab. II	1
Statics	3	Mech. of Material	3
Anal. Chem. II	6	Chem. Lit.	2
Physical Education	0	Intro. Ch. Engr.	4
		Physical Education	0
	20		20

JUNIOR YEAR

Western Civilization III	4	*Western Civilization IV*	4
Phys. Chem.	4	Phys. Chem. II	3
Org. Chem.	3	Phys. Chem. Lab. I	1
Org. Lab. I	2	Org. Chem. II	3
Unit Op. I	3	Org. Lab. II	1
Equip. Design	4	Ch.E. Proc. I	3
Physical Education	0	Unit Op. II	3
		Unit Op. Lab. I	1
		Physical Education	0
	20		19

Summer: Unit Operations Lab. II (2 weeks) 2 semester hours credit
Inspection trip (1 week) 1 semester hour credit

SENIOR YEAR

*(a) *Elective*	3	*(a) *Elective*	3
Elec. Engr.	4	*(b) Elective	3
P. Chem. Lan. II	1	Ch.E. Proj. II	3
Ch. E. Proc. II	3	Instrument	4
Met. Fund.	3	Practice of Ch.E.	3
Ch.E. Proj. I	4	Tech. Elective	3
Thermo.	3		
	21		19

* (a) Non-technical elective offered or approved by the Division of Humanities and Social Studies.

* (b) Open elective.

CLARKSON COLLEGE OF TECHNOLOGY — CHEMICAL ENGINEERING

Freshman Year

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
General Chemistry	4	General Chemistry	4
English Communications I	3	*English Communications II*	3
Fundamentals of Mathematics	4	Differential Calculus	4
Engineering Drawing	2	Engineering Drawing	2
General Physics	3	General Physics	3
Physical Educ. or Mil. Sci.	2	Physical Educ. or Mil. Sci.	2
	18		18

Sophomore Year

Chem. Process Calculations	3	Unit Operations I	3
Analytical Chemistry	2	Quantitative Analysis	2
Mechanics, Statics	3	Strength of Materials	3
Humanities I	3	*Humanities II*	3
Integral Calculus	3	Applied Mathematics	3
General Physics: Elec. & Magnetism	4	General Physics: Sound & Light	4
Physical Educ. or Mil. Sci.	2	Physical Educ. or Mil. Sci.	2
	20		20

Junior Year

Unit Operations II	3	Chemical Technology	3
Organic Chemistry I	3	Unit Operations III	3
Organic Lab.	2	Organic Chemistry II	3
Physical Chemistry I	3	Organic Laboratory	2
Physical Laboratory	1	Physical Chemistry II	3
Mechanics, Dynamics	3	Physical Laboratory	1
Applied Mathematics	3	*Liberal Studies Elective*	3
	18		18

Senior Year

Economics: Engr. Applic.	3	*Economics: Engr. Applic.*	3
Unit Operations Lab. I	2	Unit Operations Lab. II	2
Physical Metallurgy	3	Thermodynamics II	3
Thermodynamics I	3	Thesis	4
Design	3	Electrical Engr.	3
Thesis	1	*Liberal Studies Elective*	3
Electrical Engr.	3		
	18		18

MASSACHUSETTS INSTITUTE OF TECHNOLOGY CHEMICAL ENGINEERING

Freshman Year

First Term	*Hours*	*Second Term*	*Hours*
Chemistry, General	6–5	Chemistry, General	6–5
Physics	5–6	Physics	5–6
Western Civilization, Foun.	3–5	*Western Civilization, Foun.*	3–5
Calculus	3–6	Calculus	3–6
Military Science	3–0	Military Science	3–6
*Elective Subject	0 to 6	*Elective Subject	0 to 6
	42–48		42–48

Sophomore Year

Qualitative Analysis	7–3	Quantitative Analysis	7–3
Physics	5–3	Physics	5–5
Chemical Engineering	1–1	Chemical Engineering	4–6
Industrial Chemistry	3–4	*Humanities*	3–5
Humanities	3–5	Differential Equations	3–6
Calculus	3–6	Military Science	3–0
Military Science	3–0		
	25–24		25–25

Junior Year

Applied Mechanics I	3–5	Applied Mechanics II	3–5
Organic Chemistry I	4–4	Organic Chemistry II	4–4
Organic Preparations I	6–0	Qual. Organic Analysis	6–0
Physical Chemistry I	4–4	Physical Chemistry II	4–4
Physical Chem. Lab. I	2–0	Physical Chem. Lab. II	2–0
Chemical Engineering	4–6	Industrial Chemistry	3–6
Humanities	3–5	*Humanities*	3–5
	26–24		25–24

Senior Year

Electrical Engr., Fund.	4–6	Industrial Chemistry	3–6
Thesis Reports	3–0	Chemical Engineering	4–6
Industrial Chem. Lab.	10–0	Thesis	12
or		*Humanities*	3–5
Chemical Engr. Lab.	10–0	Elective Subject	8
Chemical Engineering	4–6		
Humanities	3–5		
Elective Subject	8		
	49		47

* Six units required in full academic year, may be taken in either term. Number of class hours varies according to subject, with corresponding adjustment of preparation time.

MICHIGAN STATE UNIVERSITY — CHEMICAL ENGINEERING

Fall	*Hours*	*Winter*	*Hours*	*Spring*	*Hours*
Freshman Year					
Comm. Skills	3	*Comm. Skills*	3	*Comm. Skills*	3
Nat. Science	4	Nat. Science	4	Nat. Science	4
College Algebra	5	Analytic Geometry	5	Calculus I	5
General Chemistry	4	General Chemistry	4	Engr. Communications	4
		Elem. of Engineering	0	Physical Education	1
Physical Education	1	Physical Education	1		
Military Science	1	Military Science	1	Military Science	1
	18		18		18
Sophomore Year					
Social Science	4	*Social Science*	4	*Social Science*	4
General Chemistry	4	Quantitative Analysis	3	Stoichiometry	4
Calculus II	4	Calculus II	4	Differential Equations	3
Prin. of Physics	4	Prin. of Physics	4	Prin. of Physics	4
Physical Education	1	Physical Education	1	Physical Education	1
Military Science	1	Military Science	1	Military Science	1
	18		17		17
Junior Year					
Statics	3	*Economics, Intro.*	3	Strength of Materials	5
Thermodynamics	3	Thermodynamics	3	Organic Chemistry	5
Organic Chemistry	5	Organic Chemistry	5	Physical Chemistry	4
Physical Chemistry	4	Physical Chemistry	4	Unit Operations	3
Technical Writing	3	Unit Operations	3		
	18		18		17
Senior Year					
Humanities	4	*Humanities*	4	*Humanities*	4
Design	3	Design	3	Design	4
Thermodynamics	3	Unit Operations	5	Instrumentation	3
Unit Operations	5	Accounting	3	Materials	3
Nuclear Physics	3	Electric Circuits	3	Electric Machinery	3
	18		18		17

CASE INSTITUTE OF TECHNOLOGY — CIVIL ENGINEERING

FRESHMAN YEAR

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
Anal. Geometry–Calculus	4	Calculus I	4
Physics I	3	Physics II	3
Chemistry I	4	Chemistry II	4
Composition I	3	Composition II	3
Graphics I	2	Graphics II	2
Background of Democracy I	3	*Background of Democracy II*	3
Physical Education	0	Physical Education	0
	19		19

SOPHOMORE YEAR

Western Civilization I	4	*Western Civilization II*	4
Calculus II	3	Differential Equations	3
Physics III	3	Physics IV	3
Physics Lab. I	1	Physics Lab. II	1
Statics	3	Mech. of Materials	3
Graphic Statics	1	Material Testing	1
Elements of Civil Engr.	4	Construction	5
Physical Education	0	Physical Education	0
	19		20

JUNIOR YEAR

Western Civilization III	4	*Western Civilization IV*	4
Dynamics	3	Engr. Geology	3
Simple Structures	5	Fluid Mechanics	4
Highway Engr.	4	Steel Struct.	4
Fund. of M.E.	3	Fund. of E.E.	3
Physical Education	0	Physical Education	0
	19		18

Summer School: Inspection trip, 1 week, 1 hour credit

SENIOR YEAR

°*Elective (a)*	3	°*Elective (a)*	3
°Elective (b)	4	°Elective (b)	3
°Elective (c)	3	Reinforced Concrete	4
Hyperstatic Struct.	4	Prac. of C.E.	3
Sanitary Engr.	4	Soil Mech.	4
		Hydraulic Engr.	4
	18		21

° (a) Non-technical elective offered or approved by the Division of Humanities and Social Studies.

° (b) Open Elective.

° (c) Elective to be chosen from those offered by the Department of Civil Engineering and Engineering Mechanics.

CLARKSON COLLEGE OF TECHNOLOGY — CIVIL ENGINEERING

Freshman Year

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
General Chemistry	4	General Chemistry	4
English Communications I	3	*English Communications II*	3
Fundamentals of Mathematics	4	Differential Calculus	4
Engineering Drawing	2	Engineering Drawing	2
General Physics	3	General Physics	3
Physical Educ. or Mil. Science	2	Physical Educ. or Mil. Science	2
	18		18

Summer Term of five weeks following Freshman year

Elementary Surveying	2
Topographic Surveying	3
	5

Sophomore Year

Mechanics, Statics	3	Mechanics of Materials	3
Oral Communications	3	Engineering Geology	3
Humanities I	3	*Humanities II*	3
Integral Calculus	3	Applied Mathematics	3
Engineering Materials	2	General Physics: Light & Sound	4
General Physics: Electricity & Magnetism	4	Physical Educ. or Mil. Science	2
Physical Educ. or Mil. Science	2		
	20		18

Junior Year

Economics: Engr. Applications	3	*Economics: Engr. Applications*	3
Mechanics, Dynamics	3	Fluid Mechanics	3
Route Surveying	3	Soil Mechanics	3
Electrical Engineering	3	Structural Theory I	2
Applied Mathematics	3	Electrical Engineering	3
Heat Engines	3	*Modern Civilization I*	3
Materials Laboratory	1	Fluid Laboratory	1
	19		18

Senior Year

Advanced Mechanics of Materials	2	Foundations	2
Structural Theory II	3	Structural Theory III	3
Reinforced Concrete I	3	Reinforced Concrete II	3
Concrete Testing Laboratory	1	Structural Design	4
Sanitary Engineering	4	Construction Engineering or M.S.	3
Highway Engineering	3	Machine Design	3
Modern Civilization II	3		
	19		18

MASSACHUSETTS INSTITUTE OF TECHNOLOGY — CIVIL ENGINEERING

Freshman Year

First Semester	*Hours*	*Second Semester*	*Hours*
Chemistry, General	6–5	Chemistry, General	6–5
Physics	5–6	Physics	5–6
Western Civilization, Foun.	3–5	*Western Civilization, Foun.*	3–5
Calculus	3–6	Calculus	3–6
Military Science	3–6	Military Science	3–6
*Elective Subject	0 to 6	*Elective Subject	0 to 6
	42–48		42–48

Sophomore Year

Surveying I	8–0	Surveying II	8–0
Civil Engr. Projects I	6–4	Statics & Dynamics	3–5
Physics	5–5	Civil Engr. Projects II	4–2
Humanities	3–5	Physics	5–5
Calculus	3–6	*Humanities*	3–5
Military Science	3–0	Diff. Equations	3–6
		Military Science	3–0
	28–20		29–23

Junior Year

Materials & Mechanics	6–6	Soil Mech. & Foun. Engr.	6–6
Fluid Mechanics	2–4	Materials & Mechanics	6–6
Engineering Construction	5–4	Structural Engr., Elem.	6–2
Electrical Engr., Fund.	4–6	Fluid Mechanics	3–6
Engineering Geology	4–2	*Humanities*	3–5
Humanities	3–5		
	24–27		24–25

Senior Year

Structural Design	6–0	Reinforced Concrete Design	6–0
Structural Analysis	3–6	Heat Engineering	4–5
Thesis	2	Thesis	7
Humanities	3–5	*Humanities*	3–5
Elective Subjects	24	Elective Subjects	18
	49		48

* Six units required in full academic year, may be taken in either term. Number of class hours varies according to subject, with corresponding adjustment of preparation time.

MICHIGAN STATE UNIVERSITY — CIVIL ENGINEERING

FRESHMAN YEAR

Fall	*Hours*	*Winter*	*Hours*	*Spring*	*Hours*
Comm. Skills	3	*Comm. Skills*	3	*Comm. Skills*	3
Nat. Science	4	Nat. Science	4	Nat. Science	4
College Algebra	5	Analytical Geometry	5	Calculus I	5
General Chemistry	4	General Chemistry	4	Engr. Communications	4
Physical Education	1	Elem. of Engineering	0	Physical Education	1
Mil. Science	1	Mil. Science	1	Mil. Science	1
		Physical Education	1		
	18		18		18

Summer Camp—9 weeks—Engineering Surveying—13 hours

SOPHOMORE YEAR

Social Science	4	*Social Science*	4	*Social Science*	4
Mfg. Processes	3	Structural Drafting	3	Engr. Geology	3
Calculus II	4	Calculus III	4	Strength of Materials	6
Physics Principles	4	Statics	5	Physics Principles	4
Physical Education	1	Physical Education	1	Physical Education	1
Mil. Science	1	Mil. Science	1	Mil. Science	1
	17		18		19

JUNIOR YEAR

Dynamics	4	Struc. Design	4	Reinf. Concrete	5
Struc. Analysis	6	Hydraulics	5	Transp. Engr. II	4
Physics Principles	4	Transp. Engr. I	3	Cons. Prac. & Ad.	3
Electric Circuits	3	Engr. Soil Mechanics	4	Contr. & Engr. Relations	3
		DC & AC Machinery	3	Thermodynamics	3
	17		19		18

SENIOR YEAR

Humanities	4	*Humanities*	4	*Humanities*	4
Stat. Ind. Struc.	4	Water Supply	5	Sew. & Sew. Treatment	4
Hydrology	3	Soil Mech. & Found.	4	Air & High. Pav. Design	4
Seminar	1	Elective	4	Elective	4
Elective	4				
	16		17		16

CASE INSTITUTE OF TECHNOLOGY — ELECTRICAL ENGINEERING

Freshman Year

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
Anal. Geometry–Calculus	4	Calculus I	4
Physics I	3	Physics II	3
Chemistry I	4	Chemistry II	4
Composition I	3	*Composition II*	3
Graphics I	2	Graphics II	2
Background of Democracy I	3	*Background of Democracy II*	3
Physical Education	0	Physical Education	0
	19		19

Sophomore Year

Western Civilization I	4	*Western Civilization II*	4
Calculus II	3	Differential Equations	3
Physics III	3	Physics IV	3
Physics Lab. I	1	Physics Lab. II	1
Graphic Statics	4	Mech. of Material	3
Elements of E.E.	4	Material Testing	1
Physical Education	0	Alternating Currents	5
		Physical Education	0
	19		20

Junior Year

Western Civilization III	4	*Western Civilization IV*	4
Circuit Anal.	3	Dynamics	3
Mach. I	4	Networks	4
Electronics	4	Mach. II	4
Illum. Engr.	4	Thermo.	4
Physical Education	0	Physical Education	0
	19		19

Summer: An inspection trip may be elected (1 week) 1 semester credit hour

Senior Year

**Elective (a)*	3	**Elective (a)*	3
Communications	4	*Elective (b)	3
Trans. & Dist.	4	Elect. Measurement	4
Indus. Appl.	4	Industrial Electronics	4
Tech. Elective	3	Tech. Elective	4
	18		18

* (a) Non-technical elective offered or approved by the Division of Humanities and Social Studies.

* (b) Open elective.

CLARKSON INSTITUTE OF TECHNOLOGY — ELECTRICAL ENGINEERING

Freshman Year

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
General Chemistry	4	General Chemistry	4
English Communications I	3	*English Communications II*	3
Fundamentals of Mathematics	4	Differential Calculus	4
Engineering Drawing	2	Engineering Drawing	2
General Physics	3	General Physics	3
Physical Educ. or Mil. Science	2	Physical Educ. or Mil. Science	2
	18		18

Sophomore Year

Mechanics, Statics	3	Strength of Materials	3
Integral Calculus	3	Applied Mathematics	3
Humanities I	3	*Humanities II*	3
General Physics: Elec. & Magnetism	4	General Physics: Sound & Light	4
Intro. of Elec. Engr.	4	Electric Circuits	4
Physical Educ. or Mil. Science	2	Physical Educ. or Mil. Science	2
	19		19

Junior Year

Mechanics, Dynamics	3	*Econ: Engr. Applications II*	3
Applied Mathematics	3	Fluid Mechanics	3
Econ.: Engr. Applications I	3	Electromagnetic Circuits & Transformers	3
Oral English	2	Field Theory	2
Principles of Electronics	3	Electronic Circuits	3
Steady-State Theory of Linear Circuits	3	Elec. Engr. Laboratory	2
Elec. Engr. Lab.	2	*Modern Civilization I*	3
	19		19

Senior Year

Electric Transients	3	Rotating Elec. Machines II	3
Rotating Elec. Machines I	3	Electrical Control Systems	3
Transmission Lines	3	Elec. Engr. Laboratory	3
Elec. Engr. Laboratory	3	Heat Transfer in Elec. Engr.	3
Modern Civilization II	3	*Liberal Studies Elective*	3
Technical Elective	3	Technical Studies Elective	3
	18		18

MASSACHUSETTS INSTITUTE OF TECHNOLOGY ELECTRICAL ENGINEERING

FRESHMAN YEAR

First Term	*Hours*	*Second Term*	*Hours*
Chemistry, General	6–5	Chemistry, General	6–5
Physics	5–6	Physics	5–6
Western Civilization, Foun.	3–5	*Western Civilization, Foun.*	3–5
Calculus	3–6	Calculus	3–6
Military Science	3–0	Military Science	3–6
*Elective Subject	0 to 6	*Elective Subject	0 to 6
	42–48		42–48

SOPHOMORE YEAR

Applied Mechanics I	3–5	Applied Mechanics II	3–5
Circuit Theory, Int.	7–5	Circuit Theory, Int.	7–5
Physics	5–5	Physics	5–5
Humanities	3–5	*Humanities*	3–5
Calculus	3–6	Differential Equations	3–6
Military Science	3–0	Military Science	3–0
	24–26		24–26

JUNIOR YEAR

Electronic Circuits	7–5	Elec. Energy Convertors	7–5
Fields, Materials & Comp.	7–5	Applied Electronics	7–5
Adv. Calculus for Engr.	3–6	*Humanities*	3–5
Humanities	3–5	**Elective Subjects	18
*Elective Subjects	9		
	50		50

*Heat Engineering
*Atomic & Nuclear Physics I

**Dynamics
**Heat Engineering
**Atomic & Nuclear Physics II
**Adv. Calculus for Engr.

SENIOR YEAR

Elec. Power Modulators	7–5	Thesis	7
Energy Trans. & Rad.	6–5	*Humanities*	3–5
Thesis	2	Elective subjects or additional thesis	30
Humanities	3–5		
Elective Subjects	12		
	45		45

* Six units required in full academic year, may be taken in either term. Number of class hours varies according to subject, with corresponding adjustment of preparation time.

MICHIGAN STATE UNIVERSITY — ELECTRICAL ENGINEERING

Fall	Hours	Winter	Hours	Spring	Hours
Freshman Year					
Comm. Skills	3	*Comm. Skills*	3	*Comm. Skills*	3
Nat. Science	4	Nat. Science	4	Nat. Science	4
College Algebra	5	Analytic Geometry	5	Calculus I	5
General Chemistry	4	General Chemistry	4	Engr. Communications	4
		Elem. of Engineering	0		
Physical Education	1	Physical Education	1	Physical Education	1
Military Science	1	Military Science	1	Military Science	1
	18		18		18
Sophomore Year					
Social Science	4	*Social Science*	4	*Social Science*	4
Economics, Intro.	3	Statics	3	Differential Equations	3
Calculus II	4	Calculus III	4	Prin. of Physics	4
Prin. of Physics	4	Res. Networks I	4	Res. Networks II	4
Physical Education	1	Physical Education	1	E.E. Laboratory	1
Military Science	1	Military Science	1	Physical Education	1
				Military Science	1
	17		17		18
Junior Year					
Humanities	4	*Humanities*	4	*Humanities*	4
One-Circuit Networks	4	Multi-Circuit Networks	5	Multi-Ciricuit Net. II	3
E.E. Laboratory	1	E.E. Laboratory	1	E.E. Laboratory	1
Elec. & Magnetic Fields	4	Elec. & Magnetic Fields	3	Electronic Fundamentals	3
Advanced Math.	3	Advanced Math.	3	Advanced Math.	3
Dynamics	3	Nuclear Physics	3	Thermodynamics	3
	19		19		17
Senior Year					
Networks	3	Networks	3	Non-Linear Networks	3
Electronics	3	Electronics	3	Electronics	3
Lines	3	Electromagnetic Fields	3	Electromagnetic Fields	3
Ferro-magnetic Net.	3	Dynamic Networks	3	Servomechanisms Control	3
E.E. Laboratory	2	E.E. Laboratory	2	E.E. Laboratory	2
Elective	3	Elective	3	Elective	3
	17		17		17

CASE INSTITUTE OF TECHNOLOGY — MECHANICAL ENGINEERING

FRESHMAN YEAR

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
Anal. Geometry–Calculus	4	Calculus I	4
Physics I	3	Physics II	3
Chemistry I	4	Chemistry II	4
Composition I	3	*Composition II*	3
Graphics I	2	Graphics II	2
Background of Democracy I	3	*Background of Democracy II*	3
Physical Education	0	Physical Education	0
	19		19

SOPHOMORE YEAR

Western Civilization I	4	*Western Civilization II*	4
Calculus II	3	Diff. Equations	3
Physics III	3	Physics IV	3
Physics Lab. I	1	Physics Lab. II	1
Graphic Statics	4	Mech. of Material	3
Mech. Proc. I	2	Material Testing	1
Mechanisms	3	Mech. Proc. II	2
Physical Education	0	Elements of M.E.	2
		Physical Education	0
	20		19

Summer: Practice Term (2 weeks) or co-op employment, 2 semester hours credit

JUNIOR YEAR

Western Civilization III	4	*Western Civilization IV*	4
Dynamics	3	DC–AC Circ. & Mach.	4
Fluid Mechanics	4	Prod. Engr. II or	
Energy Engr. I	3	°Intro. to Aeronautics	2
Energy Engr. Lab. I	2	Energy Engr. II	4
Prod. Engr.	3	Energy Engr. II Lab.	2
Physical Education	0	Machine Design	5
		Physical Education	0
	19		21

Summer: Inspection trip (1 week) 1 semester hour credit

SENIOR YEAR

°°*Elective (a)*	3	°°*Elective (a)*	3
°°Elective (b)	4	°°Elective (b)	4
Elect. & App.	4	Appl. of E.E.	2
Energy Engr. III	3	Practice of M.E.	3
Energy Engr. III Lab.	1	Metals & Alloys	4
Tech. Elective	4	Tech. Elective	4
	19		20

° To be taken by students electing the Aeronautics Option.

°° (a) Non-technical elective offered or approved by the Division of Humanities and Social Studies.

°° (b) Open elective.

CLARKSON COLLEGE OF TECHNOLOGY — MECHANICAL ENGINEERING

Freshman Year

First Semester	*Credit Hours*	*Second Semester*	*Credit Hours*
General Chemistry	4	General Chemistry	4
English Communications I	3	*English Communications II*	3
Fundamentals of Mathematics	4	Differential Calculus	4
Engineering Drawing	2	Engineering Drawing	2
General Physics	3	General Physics	3
Physical Educ. or Mil. Sci.	2	Physical Educ. or Mil. Sci.	2
	18		18

Sophomore Year

Mechanics, Statics	3	Strength of Materials	3
Humanities I	3	Mechanisms	3
Intergral Calculus	3	*Humanities II*	3
Metallurgy or Metallography	2	Applied Mathematics	3
Engr. Materials & Mfg.	2	Engr. Materials & Mfg.	2
Gen. Physics: Elec. & Mag.	4	Gen. Physics: Sound & Light	4
Physical Educ. or Mil. Sci.	2	Physical Educ. or Mil. Sci.	2
	19		20

Junior Year

Mechanics, Dynamics	3	*Econ.: Engr. Applications*	3
Applied Mathematics	3	*Oral English*	2
Econ.: Engr. Applications	3	*Modern Civilization I*	3
Thermodynamics	3	Thermodynamics	4
Mechanics of Machines	3	Machine Design	3
Materials Lab.	1	Fluid Mechanics	3
Engr. Mat. & Mfg.	2	Fluid Mechanics Lab.	1
	18		19

Senior Year

Elec. Engr.	3	Elec. Engr.	3
Modern Civilization II	3	*Liberal Studies Elective*	3
Applied Thermo.	4	Applied Thermo.	4
Machine Design	3	M.E. Lab.	2
M.E. Lab.	2	Technical Electives	6
Technical Electives	3		
	18		18

MASSACHUSETTS INSTITUTE OF TECHNOLOGY MECHANICAL ENGINEERING

First Term	*Hours*	*Second Term*	*Hours*
Freshman Year			
Chemistry, General	6–5	Chemistry, General	6–5
Physics	5–6	Physics	5–6
Western Civilization, Foun.	3–5	*Western Civilization, Foun.*	3–5
Calculus	3–6	Calculus	3–6
Military Science	3–0	Military Science	3–6
*Elective Subject	0 to 6	*Elective Subject	0 to 6
	42–48		42–48
Sophomore Year			
Applied Mechanics I	3–5	Applied Mechanics II	3–5
Machine Drawing	6–0	Engineering Metals	6–4
Machine Tools, Int.	4–1	Physics	5–5
Physics	5–5	*Humanities*	3–5
Humanities	3–5	Diff. Equations	3–6
Calculus	3–6	Military Science	3–0
Military Science	3–0		
	27–22		23–25
Junior Year			
Applied Mechanics III	4–8	Fluid Mechanics	4–8
Heat Engineering	4–8	Mech. Behavior of Materials	4–4
Machine Design	4–2	Heat Engineering	3–6
Elec. Engr. Fund.	4–6	Machine Design	5–4
Humanities	3–5	Machine Tool Fund.	3–2
		Humanities	3–5
	19–29		22–29
Senior Year–Power Option**			
Fluid Mechanics	3–6	Mech. Engr. Problems	3–6
Heat Engineering	3–6	Power Plant Engr.	6–6
Engineering Laboratory	4–4	Thesis	9
Humanities	3–5	*Humanities*	3–5
Additional subjects	17	Additional subject	8
	51		46

* Six units required in full academic year, may be taken in either term. Number of class hours varies according to subject, with corresponding adjustment of preparation time.

** Similar options of Aircraft Propulsion, Air Conditioning and Refrigeration, Internal Combustion Engines, Materials and Materials Processing, Design, Production, Textiles, and Nuclear Engineering.

MICHIGAN STATE UNIVERSITY — MECHANICAL ENGINEERING

Fall	*Hours*	*Winter*	*Hours*	*Spring*	*Hours*
Freshman Year					
Comm. Skills	3	*Comm. Skills*	3	*Comm. Skills*	3
Nat. Science	4	Nat. Science	4	Nat. Science	4
College Algebra	5	Analytic Geometry	5	Calculus I	5
General Chemistry	4	General Chemistry	4	Engr. Communications	4
		Elem. of Engineering	0		
Physical Education	1	Physical Education	1	Physical Education	1
Mil. Science	1	Mil. Science	1	Mil. Science	1
	18		18		18
Sophomore Year					
Social Science	4	*Social Science*	4	*Social Science*	4
Calculus II	4	Calculus III	4	Statistics Methods	3
Mach. Dr.	3	Statics	5	Strength of Materials	6
Metals & Alloys	4	Mfg. Processes	3	Proc. Analysis	4
Physical Education	1	Physical Education	1	Physical Education	1
Mil. Science	1	Mil. Science	1	Mil. Science	1
	17		18		19
Junior Year					
Dynamics	4	Theory of Mach. I	4	Theory of Mach. II	4
Thermodynamics I	5	Thermodynamics II	4	Thermodynamics III	4
Circuit Fundamentals	5	Electronics Fundament.	4	Fluid Mechanics	3
Engr. Analysis I	3	Engr. Analysis II	3	Prod. Engr. I	4
		Prin. of Physics	4	Nuclear Physics	3
	17		19		18
Senior Year					
Humanities	4	*Humanities*	4	*Humanities*	4
Machine Design I	4	Machine Design II	3	*Economics, Intro.*	3
Heat Transfer	3	Metals & Alloys II	4	Metals & Alloys III	4
Gas Dynamics	3	Inst. & Controls	3	Technical Elective	4
Mech. Lab.	3	Tech. Elective	4		
	17		18		15

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The Journal of ENGINEERING EDUCATION

May, 1956 *Table of Contents* Vol 46, No 9

Articles

Do You Know		752
Engineering Research at Iowa State College		755
Problems in Nuclear Metallurgy	Stuart McLain and Frank G. Foote	760
Field Research in Civil Engineering	Ardis White	768
Corps of Engineers Student Program	Edward J. Rising	771
UNESCO and ASEE	Howard K. Justice	776
Sponsored Research in Engineering Colleges	W. L. Everitt	779
Extra-Curricular Activities and Development	Joseph F. Zimmerman	787
Need for More "Know-Why"	Jess H. Davis	790
Liberal Scientific Education	James R. Killian, Jr.	793

Departments

In the News	795	New Members	804
YET-itude: The Unconscious Art	Lee Harrisberger		796
Graphic Science: Course for Science Majors	Eugene Paré		798
Teaching Positions Available	802		

Reports

Minutes of Executive Board Meeting		807
ECPD Accreditation—Introduction	Harold L. Hazen	814
Additional Criteria		816
Chicago Industry-Education Conference on Evaluation Report		818

Notes

Note to Authors	770	Paul Weber President	801
MIT Advanced Study School	775	Francis W. Roys V.P.	801
VDI Centenary Celebration	786	James A. Cronvich Dean	801
Engineering Directory	789	Frank C. Hockema	806
NSF Grants	792	James B. Macelwane	806
New Colorado A&M Center	794	Section Meetings	ix
ASEE Directory Changes	797	Membership Application Blank	x

DO YOU KNOW . . . .

► . . . . That if you haven't "Aimed for Ames in '56" by now you had better change your sights immediately? You have all received the Preliminary Program and know the papers and talks will be good. It will be another three-ring circus, it is true, but there will still be time to visit with old friends and make new ones. Dean Downie Smith hasn't taken over full responsibility for the weather with the same conviction that Dean Eric Walker did last year, but I know both he and the local committee are putting all the pressure they can on the "weather department."

► . . . . That the way to get to Ames is repeated for your convenience?

If you come by car—Transcontinental east-west U. S. Highway 30 and north-south U. S. Highway 69 both go through Ames.

If you come by train—The Chicago and North Western Railroad has four trains daily from Chicago to Ames, and three trains daily from Omaha to Ames. You will need to change trains at Chicago or Omaha if you come from beyond these points. The Rock Island Railroad has three trains daily each way between Kansas City and Milwaukee, but you will have to get off at Des Moines and then take a bus for the 32 miles to Ames.

If you come by bus—Ten buses leave downtown Des Moines for Ames daily, beginning at 7:00 A.M. The last bus leaves Des Moines at 11:40 P.M. Travel time is approximately one hour.

If you come by plane—The nearest point for scheduled flights is Des Moines, with an airport 34 miles from Ames. United Airlines has nine flights daily from Chicago, seven from Omaha, and one from Milwaukee. Braniff has three flights daily from Kansas City, three from St. Louis, and six from Minneapolis. Charter taxicab trips from the Des Moines airport to Ames cost $10 to $12 for one to four persons. Rental cars are available at the airport, but it is best to make arrangements ahead of time for delivery of cars to the airport. Howard Flying Service will meet flights in Des Moines and bring one, two, or three passengers to the Ames Municipal Airport, four miles from the Iowa State College campus, for a total cost of $13.20 per trip on a charter basis. Arrangements must be made by direct contact with Howard Flying Service, Ames, Iowa. The Ames Municipal Airport is also available to private planes. It has adequate facilities for servicing, and the turf runways are lighted for night landings from dusk to dawn.

► . . . . That 5500 copies of the brochure advertising the three summer schools—Construction Education, Engineering Drawing, and Humanistic-Social—have been mailed to prospective attendees? The Secretary's office sent out about 800 for whom there are addressograph plates (deans, officers, committees, etc.) and the respective Divisions sent out the others. Don't forget these summer schools in "Aiming for Ames." The dates and the Iowa State College representatives from whom information can be obtained are:

Construction Education: June 29–July 1
W. T. Hosmer, Professor of Civil Engineering
Engineering Drawing: June 20–24
J. S. Rising, Head, Department of Engineering Drawing
Humanistic-Social: June 28–30
J. E. Humphrey, Associate Professor of English and Speech

► . . . . That there were 168 applications for the 60 places in the Summer Institute for Nuclear Engineering to be held at Argonne National Laboratory from June 25 to August 17, 1956, with joint sponsorship by ASEE, NSF, AEC, and Northwestern University? About 80 engineering schools nominated men from their faculties, indicating a growing interest on the part of colleges and universities in developing staffs competent to give adequate instruction in this rapidly expanding field of engineering.

According to the *Nuclear Energy Education Newsletter* prepared by our Atomic Energy Education Committee (if you want to receive it write to the Secretary's office) the purpose of the Institute is threefold: (1) to give all its members a survey of the available sources of unclassified information in the atomic energy field, and of laboratory teaching methods particularly relevant to the field of nuclear power; (2) to give all its members in the brief time available some feeling of the interrelation of the many scientific and engineering disciplines involved in the successful design of a nuclear power enterprise; (3) to give each member a somewhat more detailed knowledge of some one part of the whole field, usually that part most closely related to his previous interest and experience.

For the first six weeks of the Institute, members will attend approximately five lectures a day three days a week. They will spend the other two days of these weeks in the laboratory, sometimes performing experiments and at other times witnessing laboratory demonstrations. For the final two weeks, each member will devote his principal effort to advanced lectures and laboratory work in the specialty of his choice.

Because of the large number of applications, plans were immediately developed to extend the program by having a similar Institute for 30 men at Brookhaven National Laboratory. The NSF has approved the program extension, but funds must come from the next fiscal year, and Congress hasn't appropriated the money as yet.

► . . . . That the minutes of the meeting of the Executive Board at Denver, Colorado, April 27 and 28, are on page 807 of this issue? Some of the highlights follow, but you will want to read the minutes to comprehend more thoroughly the many activities of the Society.

1. The "Survey of the Teaching of English In Engineering Schools" was recommended to the General Council for approval at the recent meeting of the Executive Board. Neither the Evaluation Report nor the Humanistic-Social Report now includes English, whether oral or written. Thus the study is necessary if the Society is to include all aspects of engineering education in its present "look ahead" surveys. The proposed financing was presented, and if the General Council approves the policy at its June meeting, the English Division is ready to proceed.

2. The Executive Board voted to recommend to the Constitution and

By Laws Committee and the Society Functions Committee a provision that *all* officers of the Society be members of the General Council for three years beyond the stated terms of office. At present only the President continues. The basis for the action is to make greater use of the experience and knowledge acquired by officers during their active terms.

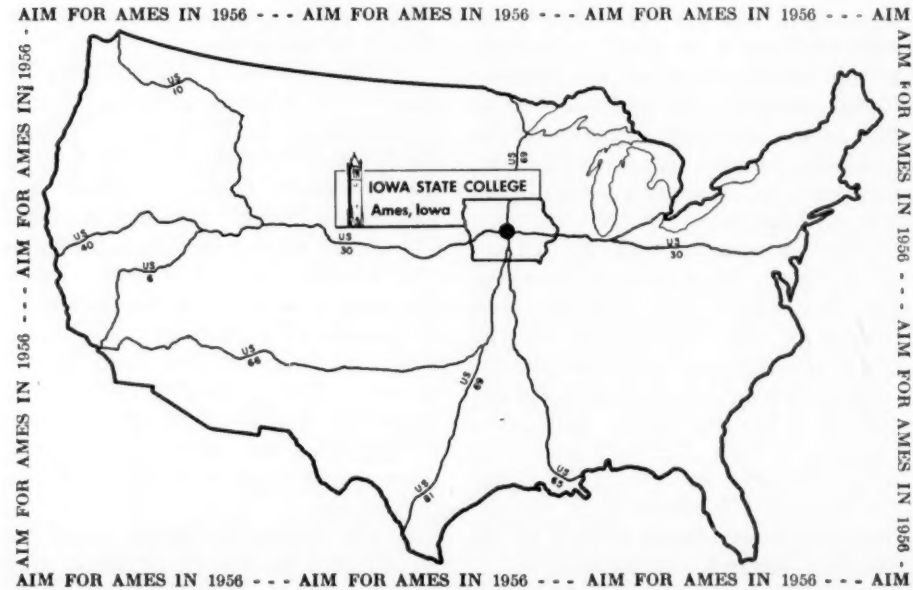
3. "Vincent Bendix Award" is the name of the gold medal to be given annually for outstanding research in colleges of engineering? The General Council authorized the Executive Board to approve a name, and ECRC recommended that of Vincent Bendix. The Bendix Aviation Corporation is assuming sponsorship of the medal.

4. At the June meeting of the General Council "dropping from membership" action will be taken on all who are still two years delinquent in dues payments as of the coming July 1. The Executive Board authorized the Secretary to follow such a policy. About 400 names are included. And there are about 300 who won't get the JOURNAL next year until they pay this year's dues. That may be unfortunate for the delinquents; we are being told kind things about the changes already made; still others are being planned.

5. Ways of increasing Society income for travel expenses were discussed. All lamented the inability to pay expenses for members of the General Council, for representatives of the Society on committees of other societies, etc., in attending meetings. To get something started, it was voted to recommend to the General Council that dues of Associate Institutional Members be increased from $50 to $150 per year, and that an *ad hoc* committee of the General Council be appointed to draft an appropriate letter which would notify the Associate Institutional Members of the change.

► . . . . That I hope to see you at Ames?

W. LEIGHTON COLLINS,
Secretary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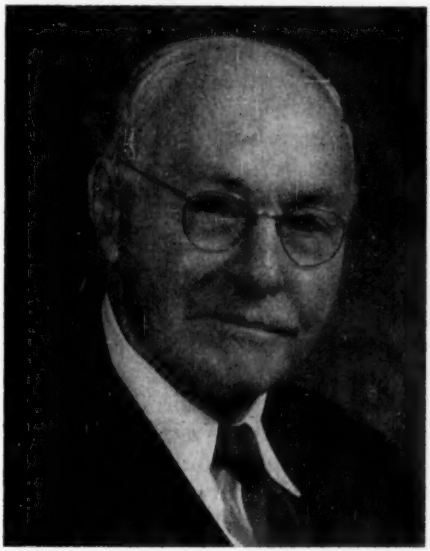
IOWA STATE COLLEGE
Ames, Iowa
US 10
US 30
US 40
US 6
US 66
US 80
US 91
US 85

ENGINEERING RESEARCH AT IOWA STATE COLLEGE

I. The Engineering Experiment Station

Iowa State College was one of the first educational institutions in the country to provide for organized research activity through the establishment of an engineering experiment station. In response to the proddings of Iowa State's vigorous dean of engineering, Anson Marston (a past president of ASEE), the Iowa General Assembly in 1904 voted a sum of money for this purpose.

Before that time, the departments of the College had carried on their work independently. Through his action, however, Iowa State was able to share with the University of Illinois the distinction of being one of the first two institutions to set up engineering experiment stations. Investigations were at once started of value to the industrial, municipal, and agricultural interests of the state.



Anson Marston, first Dean of Engineering, Iowa State College, and first Director of the Engineering Experiment Station, 1904–1932; Dean Emeritus, 1932–1949. He was President of ASEE 1914–1915.

Since then, the purposes of the Station have always been to foster and develop the industries of Iowa through engineering research and the publication of bulletins. Aid has been given constantly to develop raw materials and natural resources in the state, to increase the effective utilization of agricultural by-products, and to assist in the solution of engineering problems which face the various branches of government.

Early Progress

The General Assembly of 1904 lost no time in availing itself of the engineering research talent available on the Iowa State campus. That same year, the College was designated as the State Highway Commission, with the deans of engineering and agriculture entrusted jointly with responsibility for the commission's activities.

The first and second bulletins of the Engineering Experiment Station were issued before the end of September, 1904. Both of these bulletins showed the organization of the Station and listed a staff of five engineers. Dean Marston had proceeded with his usual dispatch in beginning the active work of the Station as soon as the legislative appropriations were available on July 1, 1904. One of the

early bulletins dealt with "The Good Roads Problem of Iowa." Though in 1913 the Highway Commission became a separate branch of the State Government's activities, the Station still does considerable work for the Commission under grants-in-aid from highway funds.

The early work of the Station included three principal types of activity: (1) engineering and scientific investigations, (2) dissemination of educational information on technical subjects, and (3) tests and analyses of engineering materials. All three types of work were pursued actively in the field of civil engineering, particularly with water supply and sewage disposal systems, drainage, and highway materials and construction. Other work dealt with problems of mining and ceramic industries of the state and with rural electrification.

In 1913, the Engineering Extension Service was established by the legislature as an independent agency to carry on informational activities in the technical field. This work was then removed from the authority of the Engineering Experiment Station. As commercial testing laboratories were established in the state, the work on tests and analysis of materials was gradually turned over to them in so far as possible.

Broad Program

Today, active work is under way on over 30 major research projects as well as on other minor investigations. These projects include activities in all of the major engineering fields. Some of the more extensive investigations are concerned with the utilization of agricultural by-products, the manufacture of fertilizers, the treatment of garbage, extraction of vegetable oils, the development of highway materials and construction methods, soil mechanics, analysis of problems in electrical transmission and distribution, and creativeness in the field of machine design.

Distribution of research results has always been an important activity of the Station. A total of 177 major Engineering Experiment Station bulletins have been issued, and numerous papers have been presented before the major engineering societies reporting the results of Station research.

The activities of the Iowa Engineering Experiment Station are supported partly by legislative appropriations and partly by contracts with sponsoring organizations. The governmental sponsors include both military and non-military groups. The budget for the current fiscal year is $414,000, of which 40 per cent comes from state appropriations. The remaining 60 per cent is obtained through research contracts with the Iowa State Highway Commission, the Federal Government, or private industry.

It is a definite policy of the Engineering Experiment Station that its research work be closely coordinated with the teaching activities of the College. Practically all of the 79 staff members have part-time teaching responsibilities, and in this way the results of current research are brought directly to the attention of Engineering students. Some of the staff members are graduate students on a part-time basis, who are thus able to obtain practical research experience while they study for advanced degrees. In addition, a number of qualified undergraduate students are employed part-time in a mutually profitable relationship.

By historical tradition, the Dean of Engineering at Iowa State College also serves as Director of the Engineering Experiment Station. Since its establishment 52 years ago, the Station has had three such directors: Anson Marston, Thomas R. Agg, and the present Dean, J. F. Downie Smith. The Associate Director is George R. Town.

Many of those visiting Iowa State College to attend the ASEE meeting in June, 1956, will undoubtedly be interested in talking to the staff members who are conducting the various research projects and obtaining first-hand information about methods and equipment. The Iowa Engineering Experiment Station issues a warm invitation for all ASEE members to visit the Station, and promises that every possible courtesy will be extended to make their visits interesting and profitable.

II. The Institute for Atomic Research

During World War II, Iowa State College played a leading part in the basic research which resulted in large-scale release of atomic energy. The Iowa State Board of Education felt that the College should maintain this leadership after the war. Therefore, on November 1, 1945, President Charles E. Friley was authorized to establish the Iowa State College Institute for Atomic Research. The Institute was set up as a separate budgetary division of the College and operates in a manner similar to that of the graduate college and experiment stations. It is thus able to conduct joint research programs on the basis of voluntary cooperation and agreement with the various deans and department heads.

In May, 1947, the United States Atomic Energy Commission formally announced the location of one of its major research facilities at Ames, to be known as the Ames Laboratory, operating as an integral part of the Institute for Atomic Research. In return, the State of Iowa has leased certain building sites to the Commission.

Among the research programs of the Institute, which include those in chemistry, physics, metallurgy, and biology, engineering has three major phases.

Varied Programs

The chemical engineering division is concerned with the development of processes for producing from ores, compounds of uranium, thorium, zirconium, and other materials of special interest in nuclear reactors. Processes which have previously been carried out only in laboratory glassware are tried on a pilot-plant scale in engineering equipment before they are adopted for commercial production. Information obtained from pilot-plant operation is essential to economical design and efficient operation of a full-scale plant.

The basic chemical engineering unit operations that are important in development of processes of interest in the nuclear field, such as solvent extraction, are studied from a fundamental point of view. Treatment of by-product and waste materials from nuclear processes is also explored, and

The central group of this photograph includes major units of the Iowa State College Institute for Atomic Research and the Ames Laboratory of the Atomic Energy Commission. The two large rectangular structures in the foreground are the Metallurgy and Research Buildings of the Ames Laboratory. At left center is the Physics Building of the College, connected with the Chemistry Building by the Office and Laboratory Building of the Institute for Atomic Research. Above the Physics Building is the white mass of the College Library, with Marston Hall, headquarters of the Division of Engineering, at the upper edge of the photograph near the left. (This view is taken from the north-east.)

other fundamental research is being carried out which promises to be useful in the design of more compact nuclear reactors.

Research in ceramic engineering involves such problems as the fabrication of high-temperature crucibles and other ceramic bodies. Determinations of the basic properties of ceramic materials are also carried out with reference to such factors as vapor pressure and reactivity toward metals or other materials, including the gases of the surrounding atmosphere, either natural or artificial.

The program of the engineering development group includes the investigation of solid and fluid reactor materials and their behavior under load. Mechanical properties, such as strength, stiffness and hardness of materials of potential use in reactors are determined; facilities include equipment for conducting creep, impact, and fatigue tests. Cooperation with other engineering groups on special design problems is an additional activity of the development group.

Special laboratories have been constructed by the Institute, and courses

have been developed in the Division of Engineering to train graduate students in the basic techniques and principles required for the general field of nuclear engineering.

New Facilities

Four new and modern buildings have been completed; two of these, the Metallurgy and Research units, have been constructed by the Atomic Energy Commission on land leased from the College. The Metallurgy Building consists of four stories and contains about 45,000 square feet of working space. The Research Building has three floors above ground, a basement, and a sub-basement; it contains about 88,000 square feet of working space.

The other two buildings have been constructed by the College. A three-story Administration and Laboratory Building, connecting the Chemistry and Physics buildings, contains about 25,000 square feet of working space and houses the administrative offices of the Institute, special research laboratories used jointly by the chemistry and physics staffs, and a large physical sciences reading room. The Synchrotron Building contains the 70-million-volt synchrotron, together with excellently equipped research and control laboratories for nuclear studies in high energy radiations and for general research in electronics. This building has been erected on a 200-acre tract near the campus, set aside for special use by the Institute for Atomic Research.

The Institute will also continue to use many of the excellently equipped laboratories in the Physics and Chemistry buildings. Special mention should be made of the various calculating machines of the Iowa State College Statistical Laboratory available for the treatment of theoretical problems. In addition, the comprehensive College Library provides valuable assistance in the research program.

Welcome to ASEE

Members of ASEE visiting the Iowa State College for the Annual Meeting will find the Institute of unusual interest. Plans are presently being completed for guided tours of convention visitors through the buildings and laboratories. Details of these inspection arrangements will be available at the convention, both for the Station and the Institute.

Thanks are due to John H. Bolton, Editor of the Engineering Experiment Station, and to Ned Disque, Director of the Iowa State College Information Service, for supplying the materials and illustrations in this group of articles on the College.

AIM FOR AMES
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EDUCATIONAL AND RESEARCH PROBLEMS IN NUCLEAR METALLURGY

With Special Reference To Fuel Elements

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The problems confronting the metallurgist in the field of nuclear materials concern characteristics of the solid state, of gases and liquids, solutions, and interactions between solid, gaseous, and liquid phases. The main variant is temperature, and the practicality of nuclear reactors as heat sources is limited by temperature just as with conventional power plants. Ordinarily, desirable properties such as vapor pressure, corrosion resistance and strength of materials are affected adversely by temperature increases. Fortunately, the cost of nuclear fuel in a fully developed nuclear-power technology is expected to be a quarter to a third of conventional fuel costs, so that lower temperatures and efficiencies can be tolerated.

Nuclear reactors differ from conventional heat plants particularly in respect to diversity of types, limits on kinds of materials that may be used because of neutron economy considerations, the presence of neutron and gamma radiation, and the production of practically unlimited amounts of heat per unit volume. The development and production of suitable materials for the reactors built to date have taken an appreciable fraction of the effort of the engineers working in the nuclear energy field. While many problems have either been solved or avoided by use of lower temperatures, the field has only been surveyed and exploratory paths cut through. Most of the practical developments still lie in the future.

Even in the present state of power reactor development, the approach to presenting, coordinating, and interpreting the wealth of information already available in the nuclear field on fuel element metallurgy, corrosion, and coolants can only be that of the fundamental considerations of inorganic and physical chemistry, physical metallurgy, and physics, including an excellent knowledge of the solid state. Therefore, we believe that the student should be thoroughly familiar with these subjects before he attempts to specialize in the nuclear field, and that a thorough working knowledge of these fundamental subjects is more important than early specialization. The undergraduate course should include a course in atomic physics, with a brief introduction to nuclear physics. A detailed discussion of reactor physics is not needed.

The metallurgist should obtain a general familiarity with the basic engineering courses, including strength of materials, the elements of chemical engineering, electrical engineering,

and possibly of structures. Particular emphasis should be placed on hydrodynamics, heat flow, and heat transfer.

We believe there is little time for specialization in most undergraduate engineering curricula. It may be proper for some schools to carry out specialization in the nuclear field in the undergraduate course but most schools should not do so. Nuclear power is a field of endeavor more than a profession. In this respect it is similar to the field of petroleum technology. Some schools have courses in petroleum engineering but most colleges look upon it as a field requiring a broad background in fundamentals rather than specific professional training.

On the other hand, specialization in nuclear power engineering can be carried out in major graduate schools to the advantage of everyone. In fact, we strongly advise that a number of universities plan graduate curricula and undertake the task of developing good laboratories in the nuclear power field. We recommend, however, that even at the graduate level most institutions continue to stress basic fundamentals and principles rather than highly practical techniques. The objective of universities should be to teach engineers how to solve *all types of problems* rather than specific problems only. The engineer can specialize sufficiently after leaving the university.

The graduate curriculum for the nuclear metallurgist should include nuclear physics, advanced work in inorganic chemistry, solid state physics, and physical metallurgy. Emphasis should be placed on laboratory work in all of these fields.

The use of examples from the field of nuclear energy in illustrating and teaching fundamental principles is of course highly recommended at both the undergraduate and graduate levels. A number of examples that may be used in teaching are mentioned in the following paragraphs.

Fuel Element Metallurgy

The preparation of fuels and fertile materials in such form that they can be used in nuclear power reactors (whether as metal or oxide in heterogeneous reactors, or as a slurry or solution in homogeneous types), introduces almost every known problem in metallurgy. The mere listing would be too long for this paper.

Preparation of the oxide fuel elements involves ceramics, while the preparation of the solutions and slurries for homogeneous reactors introduces both physical and inorganic chemistry. Some of the important problems in this latter case include the formation of colloidal suspensions and the prevention of agglomeration or precipitation of particles under the peculiar conditions existing in homogeneous reactors. Solutions of salts in water, acids, or bases, fused salts, and liquid metal solutions are all under investigation.

A very large number of problems deal with the production of uranium and thorium. The ores are largely of low concentration and vary widely in composition. In this country, uranium ores frequently occur with vanadium; some are readily separated and concentrated, others are difficult. Thorium usually occurs with the rare earths, frequently as sands. The uranium and thorium oxides are concentrated and then purified by solvent extraction.

The production of pure uranium, thorium, beryllium, and zirconium illustrates the problems of dealing with metals high in the electromotive series, which are reduced by magnesium or calcium. The application of electrolysis to fused salts of these metals is suggested as a profitable research approach.

Uranium

Uranium should have an attraction for all metallurgists, and its peculiarities can certainly supply many examples for teaching the basic principles of metallurgy. Like thorium and zirconium, uranium is difficult to produce in the purity required for reactor use. As with aluminum, purification must be carried out before reduction. Uranium goes through phase changes at 660° and 770° C and is highly anisotropic below 660° C. It oxidizes rapidly under hot working, and develops preferred orientation during rolling or other processing in the alpha phase below 660° C. Wrought uranium undergoes dimensional changes when thermal cycled or under irradiation. Uranium may be stabilized by quenching from the beta phase, from about 725° C, to decrease preferred orientation. Grain size is likely to be increased by this treatment and some warping occurs.

Uranium responds well to alloying for grain size control and stabilization against warping, growth, or surface roughening due to thermal cycling and irradiation. Alloying and heat treatment can be used to increase the water corrosion resistance of uranium.

As a metal, thorium is respectable with a cubic lattice; it is readily worked but it has low water corrosion resistance and oxidizes readily in air.

Both thorium and uranium are somewhat hazardous as a result of their natural radioactivity, so rolling or shaping must be done on hooded or well-ventilated mills under the supervision of health physicists. However, the hazard is not great. It is expected that most power reactors will use thorium alloyed with uranium-233 or natural uranium alloyed with plutonium. These two fuels are extremely hazardous and the production of the alloys and all work on the metals must be carried out in completely sealed glove boxes or in extremely well ventilated hoods.

Plutonium which has been irradiated through several fuel cycles contains higher isotopes which fission spontaneously, with production of neutrons in dangerous amounts. Manufacture of fuel elements containing highly irradiated plutonium must, therefore, be carried out by completely remote operation.

Likewise, uranium 233 irradiated through several fuel cycles contains a small amount of uranium 232, this gradually decays to thorium 228, which emits gamma rays. Uranium 233 which has been freshly decontaminated of fission products and thorium can be handled in glove boxes. After a few months, however, completely remote operations are required.

Also, sufficient 228 builds up in the thorium after a few per cent burnout so that the combination must be handled remotely even though it has been completely freed of fission products.

Cladding

Cladding thorium and uranium introduces new problems. In the first place, a metallic bond between the cladding materials, such as aluminum,

zirconium, or stainless steel, and the fuel is desirable to obtain high heat transfer rates. Such a metallic bond introduces thermal stresses due to differences in expansion of the fuel and shell. While processes for cladding uranium with aluminum or zirconium have been developed, present methods are not completely satisfactory and better processes are needed. The use of liquid sodium or lead between the fuel and cladding is also feasible, and this eliminates stresses due to differences in thermal expansion of the two metals.

Another particularly difficult problem is that of sealing fuel-element cladding materials. Because the cladding must completely enclose the fuel, at some stage in the process high integrity closures in the cladding must be made by welding, pressure bonding, brazing, or similar methods.

For example, in roll cladding uranium plate with zirconium, not only must the zirconium be bonded to the uranium core, but the various zirconium components must be bonded to each other.

This requires that all facing or mating surfaces be kept clean while heating to temperature and during the rolling process. Such cleanliness is often achieved by placing the whole assembly in sealed and evacuated boxes.

Inspection

Inspection of fuel elements is carried out by non-destructive methods, using X-rays, eletronic devices, and high frequency sound waves. These procedures have been developed to the point that inclusions, minute holes, and other imperfections can be located in the fuel element cladding or in the bond between cladding and core. Inspection techniques are particularly valuable in fuel elements, since the entrance of high temperature water through a hole in the cladding of a fuel element results in rapid corrosion of the uranium or thorium core with swelling and breaking of the fuel element cladding. As a result fission products and plutonium, along with oxidized uranium, are spread throughout the reactor system. The reactor must then be shut down and the broken fuel element removed.

In use, the fuel element is subjected to a set of peculiar conditions which have no parallel in conventional power plants. For each atom of fuel fissioned, two new atoms are formed. These fission products are trapped in the crystal lattice of the fuel metal, causing a gradual increase in volume. The fission products fly apart with tremendous velocities and, as they are slowed down, heat the surrounding atoms. The heat production causes large temperature differences and high stresses in the fuel metal.

Burn-outs

One of the perennial problems is the development of uranium alloys to withstand burn-outs of one to two atoms per hundred atoms originally present. Metal fuel which is used in power reactors may produce up to perhaps 5×10^7 Btu/ft^3 hr, while boilers produce about 2×10^5 Btu/ft^3 hr. Under these conditions a power transient or power surge for a fraction of a second may melt the fuel elements. This permits the fuel and fuel cladding to react explosively with the cooling water, releasing radioactive fission products and uranium-233 or plutonium. For this reason, reactors are built in very heavy vessels or are

surrounded by thick concrete walls and placed in sealed buildings. Oxide or ceramic fuel elements with water or liquid-metal coolants such as sodium, greatly reduce the possibility of chemical reaction. Sodium which is vaporized and permitted to escape reacts with the oxygen of the air. It is impractical to design buildings to withstand a complete instantaneous sodium-oxygen reaction. Fortunately, however, the burning of liquid sodium in air, while seemingly rapid, actually is a surface combustion similar to that of a heavy oil which has low vapor pressure.

Use of ceramic fuel elements, again, introduces the problems of low thermal conductivity and very high fuel element central temperatures and thermal stresses along with low strength materials. Some of the metal alloys of interest are pyrophoric under certain conditions even at room temperature. Others, particularly those containing plutonium, are highly toxic.

Irradiation Damage

Irradiation damage to structural materials such as stainless steel, quenched steels, mild steels, and aluminum is of interest. In general, the damage is similar to work-hardening and is of little consequence in reactor design. The ductile-brittle transient temperature in steels is raised, but apparently not enough to approach practical operating temperatures. In the case of the quenched steels, the problem may be more serious since structural and property changes now unforeseen might occur in use while many test samples gave no signs of these changes. Much work remains to be done in this field.

Corrosion is, in general, the factor that limits coolant temperatures and thus the operating temperatures of water-cooled heterogeneous reactors. On the other hand, heat transfer and thermal stresses limit the rate of heat production in such reactors.

Corrosion Problems

The corrosion problems of particular interest in the heterogeneous reactor field are high-purity water-corrosion of aluminum, zirconium, and stainless steel. Corrosion in homogeneous reactors involves acid solutions and their attack on zirconium and stainless steels. The attack of liquid metals on aluminum, zirconium, stainless steels, and other structural or cladding materials is usually a solution effect rather than true corrosion. In some cases, grain boundary attack and selective removal of some components have been observed. Erosion combined with corrosion and dissolution is important in many applications, particularly in the attack of water and its solutions on aluminum and stainless steel.

An example of the use of basic knowledge of liquid-solid interactions is that of the study of aluminum corrosion. Aluminum corrodes rapidly and pits badly in ordinary water at temperatures as low as 100° C. The corrosion is much less severe in high-purity water. At temperatures high enough to give steam pressures of interest in the power industry, the corrosion rates are higher. Tests beginning during the war and extending to the present time have demonstrated that 2S Al may be used in high purity water at temperatures as high as 230° C. The water must be pure, however, with resistivity in the range of 10^5 to 10^6 ohms per cm. The rate

of flow must exceed about 8 ft/sec to prevent pitting caused by formation of various ions in static solutions. While corrosion rates are initially high, they decrease rapidly to acceptable rates in about two weeks by adherence of the hydrated oxide film. Addition of acid decreases the corrosion rate. At temperatures of about 275° C, the corrosion rate becomes high, and test samples disintegrate in a few hours regardless of the purity or pH of the water.

An examination of the corrosion mechanism in terms of the interfaces between the solid metal, its oxide film, and the liquid water phases indicated that the hydrogen emitted during the oxidation of the aluminum was diffusing into the metal and causing surface blisters. Prevention of the hydrogen penetration by use of nickel or copper alloys was possible, since these metals act as hydrogen cathodic centers and cause release of the hydrogen as molecules to the water. Tests indicate that aluminium alloys of this type may be usable as a fuel-cladding material for nuclear reactors in high-purity or slightly acidified high-purity water at temperatures up to 300° C.

The question of mass transport has required a complete theoretical investigation of how solid corrosion particles form in the cooling water and how they are deposited on active surfaces. This work made use of basic theoretical considerations to solve a very tough engineering problem. The corrosion resistance of zirconium is much higher than that of aluminum. Zirconium alloys have been developed that result in lower and more reliable corrosion rates than occur with pure zirconium.

The problems of coolants are intimately associated in many respects with corrosion. For example, when a metallic fuel element cladding fails and the coolant is water, the coolant will enter the hole in the fuel element and cause rapid corrosion of the uranium or thorium. Special alloys, as noted above, are able to reduce the rate of corrosion. However, corrosive fission products and uranium or thorium oxidation products will become mixed with the coolant and will be carried through the entire coolant system. The coolant cleanup method must be able to remove these fission products and any uranium-233 or plutonium present as well as the fuel.

Coolant Requirements

In homogeneous reactors the fuel is slurried with or dissolved in the coolant. In this case the requirements for the coolant are that the solution or slurry not precipitate or settle out, that the resultant liquid not be impossibly corrosive, and that leaks not be allowed to occur. Leaks are serious and hazardous in homogeneous reactor systems. Leak-proof systems including heat exchangers are complex and expensive. Cheaper, more easily repaired pumps, heat exchangers, and valves are needed.

Liquid metals and their handling involve additional problems. Heat transfer rates of 500,000 to 2,000,000 Btu/ft^2 hr using liquid metals and 300,000 to 1,000,000 using water are desirable in power reactors. High heat transfer rates are desirable in the heat exchangers, but because stainless steel is used, over-all coefficients of only 200 to 600 are finally obtained. Very large heat exchangers are therefore required.

Under normal operating conditions,

maintenance of the coolant in water-cooled heterogeneous reactors involves the removal of corrosion products by ion exchange and filtration, the separation and recombination or discharge of gaseous decomposition products, and the control or suppression of solid corrosion deposits on heat transfer surfaces. In case of fuel element failure, gaseous fission products and solid oxidized fuel particles must also be removed. Since all materials are radioactive, the system must be operated remotely, including handling the ion beds and filters.

In the case of sodium-cooled reactors, the sodium can be purified by cooling and passing over steel-wool filters to trap precipitated and insoluble materials. Special means must be provided in case of fuel element failure. The purification of homogeneous reactor coolant properly belongs in a discussion of fuel recovery and decontamination. In water slurry or solution reactors, water decomposition products must be continuously separated and recombined, while the gaseous fission products are separated and stored. Boiling-water reactors introduce other operational problems.

Gas coolants have been used at temperatures in the range of a few hundred degrees Centigrade. Future gas cooled reactors will be operated at temperatures of 650° C and higher, using helium or other gases. Ceramic fuel elements, alloys resistant to high temperatures, and special gas compressors and turbines must be developed before these reactors become practical. Gas turbine cycles combined with steam cycles promise higher thermal efficiencies than those of the most efficient conventional power plants in use today.

The problems mentioned above plus many others confront the educator when he considers how and what to teach in university courses. Obviously, it is impossible to discuss the details of the many ways in which these problems have been solved. Any practical solution of a problem is likely to be outdated before a student can finish his training. Further, the entire nuclear power field is in a state of flux with a general reduction of the theoretical aspects to practical applications.

What to Teach

This brings us to the only practical solution: to teach general fundamentals as mentioned earlier. The teaching of these fundamental principles, plus practical laboratory work of a general nature, is all that can be covered adequately in the undergraduate courses. The ideal procedure is to teach and demonstrate by student experiments what takes place, for example in rolling uranium as well as mild steels. The use of uranium along with steel and other materials will illustrate such phenomena as the effects of anisotropy on dimensions, the importance of folds, and trapping of inclusions. The unique properties of uranium should make it of general interest to students.

The use of uranium and zirconium to teach the basic methods of roll bonding is another example, as is the use of this same system for teaching the principles of cast-bonding and extrusion.

If it is desired to have graduate courses in the nuclear field, one certainly should be on nuclear materials and should include extensive laboratory work. An outline of the lectures in such a course follows:

Introduction to Reactor Materials (U, Th, Pu, Zr, Be, Ti)
Purification and Reduction to Metal
Melting and Casting
Fabrication of the Metals
Physical Metallurgy of the Metals (Including Textures, Alloying, Heat Treatment, Corrosion, Thermal Cycling, and Irradiation Effects)
Fuel Element Manufacture (Including Canning, Roll Bonding, Extrusion Cladding, Powdered Metallurgy, Ceramics)
Inspection and Testing
Behavior of Fuel Elements in Reactors (Including Clad Failures, Distortion, Burn-out)
Structural Materials (Al, Stainless Steel, Zr, Ti)
Liquid Metals (Na, K, Pb, Mg, Bi)
Development Procedures (Including Sample Irradiations and Prototype Fuel Element Tests)

The courses at the graduate level can be supplemented and extended by on-the-job and thesis training at one of the National Laboratories.

Knowledge Expected

A discussion of what Argonne National Laboratory expects in the men employed for development work in materials can be given quite briefly. Argonne has an extensive Metallurgy Division with a continuous requirement for well-trained men. It is desired that the men have an excellent knowledge of the fundamentals of physical chemistry, physics, and metallurgy, or training in ceramics, corrosion, and physics—particularly the solid state. A practical command of the equipment, procedures, and principles involved in metallurgical research and development is also helpful. Specific knowledge of the nuclear field is not a requirement though a broad understanding of the principles involved is highly desirable. Special facts will be picked up quickly on the job.

In summary, we would again like to emphasize teaching the fundamentals of physics, chemistry, and metallurgy, with laboratory experience and examples from the nuclear and other fields, as the undergraduate preparation for work in nuclear materials. A graduate course in nuclear materials should build on this fundamental knowledge and extend the metallurgist's experience in other fields, rather than simply specialize in nuclear materials. The metallurgist is expected to play a role in research and development, in manufacture of fuel elements and reactor components, and in the application of these materials to power plant operations. He must be able to face new problems daily and to apply fundamental knowledge in solving such problems.

Editorial Note: The article above is revised from an oral presentation, one of five at the session sponsored by the ASEE Committee on Atomic Energy Education (P. N. Powers, Chairman), at the Cleveland EJC Nuclear Engineering and Science Congress, December 14, 1955. Through the courtesy of the session co-chairmen, C. K. Beck and C. F. Bonilla, it is hoped to publish in the June issue the other immediately available paper of the group.

THE ENGINEERING TEACHER AND FIELD RESEARCH

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If research is defined as a critical and exhaustive investigation or experimentation, the aim of which is revision of accepted conclusions in the light of newly discovered facts, it is sometimes difficult to tell where laboratory research ends and field research begins. In general, however, it seems proper to say that field research is carried out on a finished product, structure, or part of a structure under actual conditions of normal use.

The following would be legitimate examples of field research: road testing of an automobile, flight testing of an airplane, a vibration analysis of a steam turbine, or an experimental determination of stresses caused by train loads on a completed railway bridge. Whether formally recognized or not, field research has played an extremely vital part in most technological advances, in improvement of basic design techniques, and in development of production and construction procedures.

Examples of Field Research

In civil engineering, many productive field research programs have been carried out, especially in soil mechanics. Need for such studies is very great, as theoretical progress in some phases of soil mechanics is now being impeded by lack of performance data on existing structures. In a 1945 article entitled "Shipways with Cellular Walls on a Marl Foundation," Terzaghi, Fitzhugh, and Miller explained the construction of some large piers. These were unique because the procedures and design were changed to conform with new data gathered during construction. Piezometers have also been used in hydraulic-fill dams to warn of unsafe neutral pressures in extremely poor foundation soils.

Such structures could not have been built with safety or reasonable economy, if at all, without careful research.

The anchored bulkhead is a steel-soil structure used to retain earth fills. It also cannot be studied by exact stress analysis techniques, and field research is of value in design and construction. In 1949, Professor Duke of UCLA conducted a comprehensive test program on an anchored bulkhead at Pier C in Long Beach Harbor, California. One of his most interesting findings was that settlement of the hydraulic fill caused a significant increase in stresses imposed on anchor rods. These loads were later relieved by digging through the fill and loosening the anchor rod turn-buckles. The increased stresses would undoubtedly have caused failure of the bulkhead had they not been detected by this field research.

In the same way, understanding of the actual consolidation process in

loaded soil has been greatly aided by careful field settlement measurement programs. Comparing the results of these field settlement measurements with those for laboratory settlement analysis has made possible greater accuracy and validity for laboratory methods.

Piles and Bridges

The way in which load is transferred from a bearing pile to the supporting soil is complicated greatly by the variable nature of different soils. Field tests have given much information regarding the actual nature of the load transfer, thus leading to more accurate design of bearing piles.

The common slab-and-beam highway bridge is a highly indeterminate structure and is normally designed by approximate methods. Field deflection and stress-measurement programs have aided greatly in understanding the behavior of these structures, again allowing more accurate design procedures. The same tests have given much information regarding "composite action," in which the concrete slab acts with the steel girders to form T-Beams.

Instrumentation

No effort has been made here to give all requirements for a successful field research program, but a few important ones can be mentioned. Where practical, all measurement procedures should be checked by independent methods, as SR–4 readings by a few Carlson or other types of strain gages. The simplest practical instrumentation should be used, designed for long life, wherever it is possible that long-time readings may be desired. Installations should be protected as much as possible, both from construction procedures and from the idly or maliciously curious. A thorough and complete diary, supplemented by photographs, is very useful in field research work and should be faithfully kept.

Objections to Field Research

In spite of the many advantages of field research, there are those who object to it for various reasons. As an example, contractors and construction engineers are primarily concerned with the *completion* of building, and are thus impatient with the field research engineer whose work occasionally slows down progress, or may demand changes in the usual erection procedures. Field research frequently furnishes information of value to the engineers and contractors, but it is sometimes difficult to convince them of this fact.

In addition to the resistance offered by the contractor and the engineer, carelessness or ignorance on the part of workmen often plays havoc with field research programs. For example, strain-meter leads have been cut by construction employees because these leads interfered in some way with their work. Field research men must be very careful to see that as many workers as possible understand what they have been doing. Success of the test work in no small way depends upon the good will and assistance of the contractor and his employees. Field research done completely apart from any other type of work is most desirable, of course, but is seldom possible.

Financing

Financing of field research is a question which always arises early, and it seems logical that financing

should be largely done by the party benefiting most from the results of the research. This might be a manufacturer, a producer of building materials, a builder, a contractor, or even an independent research engineer.

Field research is often done by graduate students or faculty members of colleges and universities working on actual projects. In this case, financing can conveniently be done, as by the University of California at Los Angeles, through a "Service-to-Industry Contract." Under this agreement, industry purchases instruments and finances the test installation, while university personnel design the system, obtain the data, and interpret the results. Unless the research projects are classified, the university holds publication rights, but makes confidential progress and final reports to the industry or other organization involved.

Value of Field Research

Productive field research must be done in accordance with sound, basic engineering principles. Being more broadly familiar with these principles than any other group, the teaching profession has a moral obligation to encourage and participate in field research. The field engineer and contractor, on the other hand, have a vital skill in practical judgment which the engineering teacher may not have had the opportunity to develop fully. Thus the engineering teacher benefits significantly from field research through having his theoretical knowledge tempered and amplified by experience in actual field design and construction techniques. Even more specific gains may be represented by the acquisition of first-hand information on field experimental stress analysis techniques.

Another very important benefit derived from responsible participation in an extensive field research program is a strong and lasting recognition of the extreme importance of careful, sustained, and integrated planning throughout the life of the research program. Such planning is useful to the success of any venture, but in successful field research it is vital. As a final note, it is of interest that engineering teachers sometimes get paid for field research work, and that good opportunities are usually provided for professional publications.

NOTE TO AUTHORS

Please see that your *name* (as you wish it printed) is on your manuscript, with your title and professional affiliation in enough detail to serve as a mailing address. Other introductory data such as presentation before the ASEE or other society, previous publication or adaptation, and divisional recommendation, are also most helpful. (This may sound silly, but manuscripts have been received without names, and usually lack all other facts.) Thanks for your cooperation!

CORPS OF ENGINEERS SUMMER STUDENT PROGRAM

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Engineering students who obtain summer work with an outside engineering organization have an excellent educational opportunity, and most college programs suggest that undergraduate study be supplemented in this way. If utilized properly, such experience enables students to see practical applications of topics covered in their classrooms; often the project work provides valuable background for courses not yet taken. Perhaps most important of all, vocational experience often demonstrates the usefulness of subjects previously considered of little worth. These changes in opinion or value judgments about academic material can open up whole new areas where previously little interest or effort was expended.

During the summer of 1955, the author participated in the Summer Student Training Program of the Kansas City District, Corps of Engineers, which had requested a careful examination of their program. A resumé of the study findings may be of help to faculty members who wish to evaluate the educational contribution of summer work programs. It will also make available specific data to assist counseling of students in regard to this or similar programs.

History and Administration

The Summer Student Training Program was originated to interest students in the Corps of Engineers as a career, to give training, and to help with the seasonal overload of subprofessional work characteristic of a large engineering organization. Aims have not been changed since the inception of the program as a casual procedure in 1939. In 1950 it began to be regarded more seriously, and expansion and formal organization were begun at a District level (Kansas City). In 1952 coordination was taken over at the Division level (Missouri River) and the program emerged into the Summer Student Training Program existing today.

Projects in the District are surveyed for openings early in the spring. Following the preliminary review, contacts are made with students during the regular interview trips to the local colleges; a second survey is then conducted to confirm the openings. Finally, commitments are made matching the interests and qualifications of the student to the job as fully as possible within the inherent limitations of the situation. Students selected early in their college careers are encouraged to return during subsequent summers, and are then given preference in assignments.

The students for this program are taken from many engineering curricula: aeronautical, mechanical, electrical, chemical, mining and metallurgy, mathematics and physics. Civil engineers are, however, much the

most numerous. Trainees are chosen primarily from students finishing their sophomore or junior year, although occasionally students are selected who have finished only one year. Shortly after the student starts to work he is called to the District Office (Kansas City) for a day of orientation. Then he returns to his assignment, where he works throughout the summer. The Division Office has directed that each student is to be assigned to at least two different types of work during the summer. This policy is implemented wherever possible.

Assignments of the students are varied. Several are placed in the drafting offices and various branches such as Hydrology, River Operations, Planning and Reports, and the Laboratory. The students work *with* and *for* engineers. As trainees, they are encouraged to ask questions and contribute ideas on current problems. Reference books and current articles are made available, especially in branch office assignments. There is opportunity for professional growth in all positions surveyed. The amount of opportunity made available depends considerably on the student's supervisor; how well the opportunity is used depends on the student himself.

Survey Method

The data for this study were secured from the trainees by two sets of questionnaires. One set was completed by the students at the beginning (23 responding) and one at the end (19 responding) of the summer of 1955. Sixteen pairs of matching questionnaires were obtained. As a validation and extension of the data collected by questionnaire, more than three-fourths of the students and their supervisors were then individually interviewed.

Discussion of Results

Work assignments of the students can be grouped conveniently under survey parties, drafting office, District branch office, and field office. Using this breakdown, an analysis is given in Table I showing the number of different types of tasks assigned the students, the number of courses they utilized from their curriculum, and the number of courses for which student value judgments were changed.

It should be noted that these results are given as reported by the students. This distinction is necessary because two important points were brought out in personal interviews with the students and inspection of their jobs. First, many of the students were not mature enough to derive much of the benefit available; second, the positions actually contained many elements classifiable under more course titles than the students reported.

A conclusion that can be drawn immediately from this table is that the best assignment for both quality and quantity of experience is one in a field office. It is also apparent that all job assignments in this program provide valuable background and experience for the participating students. The students report an average of 3.8 courses used in summer work.

Skills Transferred

An analysis of the transference of skill between the summer job and the school curriculum indicates that of the average 3.8 courses used in summer work, the most significant were mathematics, drawing, and surveying. A total of twenty-four separate course

titles are reported; these cover all the so-called basic subjects of the first two years, such as mathematics, physics, English, economics, and engineering materials.

Breaking down the course utilization by academic sessions shows that students finishing their junior year indicate only slightly more course work that had proved more important than previous estimates would have indicated. The overall average change in value judgment is 1.1 courses. Students working their first summer in the program show an average change of 1.5 courses, compared to 0.2 courses for students who have worked in the program previous summers. Table I

TABLE I

Relation of Assigned Tasks To Student Opinions

	Field Office	Branch Office	Survey Party	Drafting Office
Average number of different tasks assigned	4.0	3.6	1.0**	1.0*
Average number of courses in curriculum utilized	5.0	3.0	2.0	3.5
Average number of changes in value judgments of students in first year of program	4.5	1.0	1.0	0.8

* Students report variation in type of drawing done.
** Students report some rotation of jobs within the survey parties.

consistent with their job (average 4.5) than students who have completed their sophomore year (average 4.0). The fact that these figures are very close shows that the work done draws most heavily on the basic courses taken in the first two years. These data correlate with the part basic subjects play in the changes of value judgments, and transference of skills.

An analysis of course utilization on the basis of curriculum indicates a high degree of consistency between school work and experience for civil, agricultural-flood control, mining and metallurgy, mechanical engineering, mathematics and physics majors; a low degree of consistency is indicated for chemical, aeronautical, and electrical engineers.

Value Changes

At the end of the summer the students were asked to list those courses shows those first year students who worked in a field office have the highest change in value judgment (average 4.5 courses) compared to all other first year groups; the drafting group has the lowest change (average 0.8 courses). The field office and District branch office groups show an intermediate change (average 1.0 courses). More than half of the courses mentioned in response to this question can be considered basic subjects.

Psychic Effects

A comparison of the responses to questions dealing with the "psychic income" aspects of jobs, asked at the beginning and end of the summer, shows that the effect of the summer job was primarily to reinforce original opinion. The students were asked to rearrange, according to importance, the following items:

a. Recognition
b. Security
c. Salary
d. Power
e. Respect
f. Health and safety
g. Variety of tasks
h. Social satisfaction
i. Self expression
j. Chance for advancement

The three items that were consistently noted as most important on both questionnaires are "chance for advancement" first, with "security" and "salary" indistinguishable as second and third. "Power" is the lowest ranking item on both questionnaires. Other items of minor importance are "satisfaction" and "health and safety." The students clearly indicate "respect" more important on the final than on the initial questionnaires.

Students were asked at the beginning and at the end of the summer whether they intended to work with the Corps of Engineers as a permanent career in the future. Based on the answers and supporting information available from both interview and questionnaire, the program did not appreciably influence trainees either positively or negatively toward the Corps of Engineers as a vocational goal.

It is interesting to note that the average age of the group not interested in a permanent job with the Corps is 19.5 years, compared to an average of 20.9 years for the "undecided" group, and 23.7 years for the "interested" group. This may be significant and invites speculation.

Summary

From the point of view of the participating student, the Summer Student Training Program of the Corps of Engineers is successful. This success may be judged in terms of four considerations.

1. In general, the students receive intensive experience in fields covered by several of the courses in their curriculum. In some cases the students receive wider training, involving experience in areas covered by as many as six or eight courses.

2. The new skills the students learn are to their advantage. Most of the trainees are not mature enough, however, to take full advantage of available experience or opportunities to gain new skills.

3. Students' changes in value judgments about courses in the curricula can be a significant advantage.

4. The psychic factors relating to the vocational goals of the students underwent reinforcement as a result of work experience.

From the point of view of the Corps of Engineers, the Summer Student Training Program meets its goals with only limited success.

1. The return to the Corps on their dollar invested in student labor is good. This opinion is expressed by the supervisors for whom the students work. Were this the only consideration, the program would be justified.

2. The benefits the Corps desires in the field of engineering recruitment are not presently being obtained by this program; there appear, however, to be no negative effects on engineering recruitment.

3. The country as a whole benefits by the training the Corps of Engineers gives the engineering students, whether or not the students choose a career in the Corps.

Major Advantages

Perhaps the most important advantage to the students of this or similar programs is not open to objective analysis. It is the opportunity for personal experience that the students gain by working with practicing engineers. Personal experience is the only way for students to find out what being an engineer actually means. By questioning these men, many of whom are authorities in their field, students can learn much that will help with their own professional development. Finally, in programs of this type, students learn to practice patience, accuracy and thoroughness—the primary tools of an engineer, and highly desirable additions to the standard curricula in engineering.

MIT School for Advanced Study

The establishment of a School for Advanced Study as an integral part of MIT's organization was announced January 4, 1956, by Dr. James R. Killian, President, Massachusetts Institute of Technology. The new school will provide means by which post-doctoral scholars from all over the world can join the MIT faculty in high-level theoretical studies and research. Professor Martin J. Buerger, former Chairman of the Faculty, has been appointed Director and Institute Professor, effective July 1, 1956.

"The advance in knowledge makes it increasingly important for scholars to pursue advanced study beyond the level of the graduate school and doctor's degree," Dr. Killian pointed out further. "In fact, the advancement of American science particularly requires more post-doctoral study and research in educational institutions.

"In its initial embodiment the school will be simply an organizational entity, but we hope ultimately to provide a center and adequate housing for fellows and guests and by this means to gain the advantage of cross-stimulation of ideas which occurs when learned and ingenious men are brought together in close social contact."

Scholars who are invited to MIT for advanced study will have the status of "fellows" in the school. This year there have been approximately 100 such people from fifteen countries studying at the Institute and they have been registered as "guests" or "visiting fellows."

Dr. Buerger added this comment, "We welcome such scholars and believe we can be of greater help to them by establishing the new school. Much can be gained in science and engineering through the interchange of ideas. Close association and intimate discussion between men in the same field of research, or in different fields, can produce new insights."

UNESCO and ASEE

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The writer represented the American Society for Engineering Education at the Fifth National Conference of the U. S. National Commission for UNESCO (United Nations Educational, Scientific and Cultural Organization) at Cincinnati, Ohio, November 3–5, 1955. Along with the many other organizations designated to nominate members to the National Commission, ASEE may well play a significant part in UNESCO affairs. For this reason the Secretary of ASEE asked that the Society membership be informed, through an article in the JOURNAL, of the aims, activities and accomplishments of UNESCO.

Objectives and Accomplishments

UNESCO is one of the specialized agencies of the United Nations. Its avowed objective is to contribute to world peace and security by promoting collaboration among nations through education, science, and culture. An underlying premise of its constitution is that "since wars begin in the minds of men, it is in the minds of men that the defenses of peace must be constructed."

The activities of UNESCO are international in scope and cover a broad field of direct aid to member states. An important contribution in the field of science and world understanding was the establishment, during the past five years, of a European Center for Nuclear Research (CERN) at Geneva, Switzerland. CERN was the outgrowth of an idea originally proposed by an American delegate to a conference in Florence, Italy, in 1950. UNESCO guided the undertaking from conception to completion. Exhaustive legal studies by UNESCO's Secretariat and copious exchanges of views finally culminated in the signing of a treaty on the project, at UNESCO House in Paris, by representatives of twelve European governments on July 1, 1953. The cornerstone of the main building was laid on June 10, 1955. All the governments are sharing the cost of construction, equipment, and administration, estimated at about $28,000,000 for the first seven years. UNESCO's outlay was a modest $25,000 over a three-year period.

This project is typical of many in which UNESCO plays the role of promoter, and it helps us to understand why the agency can operate on an annual budget of only $10,000,000.

No complete account can be given here of UNESCO's extensive program of aid to the less developed areas of the world. Assistance is provided in the establishment of museums, libraries and scientific laboratories; in the improvement of school and university education; in the preservation of art and historical materials; and in many other fields devoted to economic and social development. Such assistance enabled India to open its first modern public library in New Delhi, and Egypt to found at Sirs el Layyan an education center for the Arab States.

Some Current Plans

UNESCO is now grappling with grave economic and social problems peculiar to the vast arid zones of the Middle East and South Asia. It is also struggling to increase mutual understanding among nations through a global spread of both Eastern and Western cultures. No small part of this project is the supplying of good reading materials for new literates educated under the leadership of UNESCO.

Another project is closer to home. This concerns education in Latin America. The ultimate objective is the extension of free and compulsory education in all the independent nations south of the Rio Grande. Existing laws provide for such education in all these countries, but little has ever been done to implement or to enforce them. Plans call for the project to be launched in 1957, after a joint regional conference of UNESCO and the Organization of American States in Lima, during April of 1956.

The United States National Commission

The United States National Commission for UNESCO represents this country in the world organization. At the head of UNESCO is the Director General, with headquarters at the Secretariat in Paris, France. The U. S. National Commission consists of 100 appointed members, of whom 60 are in non-governmental organizations, 25 are representatives of Federal, state and local governments, and 15 are appointed at large by the Secretary of State.

The Commission is required under Public Law 565 (79th Congress) to call general conferences for the discussion of matters relating to the activities of UNESCO, "to which conferences organized bodies actively interested in such matters shall be invited to send representatives. . . ." Conferences have been held as follows: Philadelphia, March 1947; Cleveland, March, 1949; New York City, January, 1952; Minneapolis, September, 1953; and Cincinnati, November, 1955.

The Cincinnati Conference

The theme of the Cincinnati conference was *The First Nine Years—An American Appraisal and Forecast.* Including visitors from foreign countries, total attendance was approximately 1000, of whom about 800 were official delegates of organized bodies like the ASEE. Besides four plenary sessions, there were meetings of 17 smaller work groups averaging 40 to 50 delegates each. With slight changes in wording for clearer understanding, topics for open discussion by these groups were as follows: Basic Knowledge for Better Living; Meeting the Need for Free and Compulsory Education; Mutual International Understanding through Schools; The Role of the College and the University in Advancing Mutual Understanding; Mutual Understanding through Adult Education; Religion and International Understanding; Cultural Institutions; The Gift Coupon Program; America's Million Ambassadors (tourists, exchange persons); Man against the Desert; Human Problems and Technical Change; Human Relations; Breaking the Language Barrier; Music —a Universal Language; The Dramatic Arts and Mutual Understanding; Visual Arts in the Creation of Peace; Increasing Communication among Peoples.

Delegates attended group meetings of their own choice. As a representative of ASEE, the writer affiliated himself with the group which discussed The Role of the College and the University in Advancing Mutual Understanding. It soon became clear that institutions of higher learning differ widely in the extent of their participation in the affairs of UNESCO. Many do little or nothing that is directly traceable to planned cooperative effort. This situation apparently stems from inadequacy of communication between UNESCO and the colleges and universities. Accordingly, the group passed a resolution that the educational members of the U. S. National Commission be asked to convene a major conference to advance the interrelationship between UNESCO and American institutions of higher education.

It was suggested that UNESCO Student-Faculty Organizations be established in all colleges and universities and that closer cooperation be sought with the International Universities Association. UNESCO representatives on college campuses were urged to take the initiative in strengthening programs dealing with international relations and to solicit administrative encouragement and support.

Participation of Societies

A recent venture of the American Association for the Advancement of Science is indicative of the way educational, scientific, and cultural societies can contribute to the fulfillment of UNESCO objectives. The UNESCO Arid Zone Program contemplated for the Middle East and South Asia was recognized as having deep potential significance for the United States. Vast regions of our West and Southwest are arid or semi-arid. Realizing that the problems of these areas affect the welfare of the nation as a whole, the Southwestern and Rocky Mountain Divisions of the AAAS and the national parent society organized an International Symposium and Conference on Arid Lands in New Mexico. This conference was held in Albuquerque in the summer of 1955. Enthusiastic and vigorous support was given by UNESCO through immediate inauguration of plans to expand its arid zone program. It was reported at the Cincinnati meeting that efforts were being made to form a United States Commission on Problems of Arid Lands. The AAAS is to be commended for its initiative and resourcefulness in generating action on a program of such paramount importance to the United States of America.

Conclusion

The ASEE, through its representative to UNESCO and with the cooperation of Society members who have served as consultants in several foreign countries, should keep constantly alert to the needs of UNESCO in the advancement of educational, scientific, and cultural relations among the peoples of the world in the cause of peace and security.

THE PLACE OF SPONSORED RESEARCH IN THE ENGINEERING COLLEGE

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A paper presented at the Southeastern Section meeting, ASEE at Knoxville, Tennessee, April 15, 1955

In university circles there are few topics under more active discussion than the relation of sponsored research programs to the educational process. This is an understandable topic of concern because, the current costs of engineering and research programs being as high as they are, it is only through outside sponsorship that most educational institutions are able to make significant contributions. Also, because the largest portion of sponsored research is carried on in engineering colleges, we necessarily set the standards for such contracts, and the indirect effects of our actions on our colleagues in other colleges must not be overlooked.

About certain questions we are, of course, in basic agreement. We all assert that no research program should be accepted which in any way violates our fundamental purpose of preparing students to be good citizens and leaders in an economic and political future which promises to depend more and more upon technology. If our educational institutions succumb to commercial pressures or to desire for selfglorification, we can hardly expect our students to have the proper incentive for service to others, without which our civilization may not survive. On the other hand, we all know that if we cannot keep our financial books in balance, if we cannot maintain staffs of high quality, or if we fail to produce as well as disseminate new ideas, we are equally doomed to failure, either individually or collectively.

Beyond these points, however, our discussion often takes on the sharp tone of a debate over the merits of "research versus teaching" and argument as to which of these is the more important, particularly for the advancement of the individual teacher. Such debates are generally inconclusive and unproductive. They do indicate, however, necessity for defining closely the objectives of any research program in an educational institution. In so defining, it is essential to be perfectly honest. I stress this point because there are strong temptations to voice certain considerations but, perhaps unconsciously, to be influenced by others.

Research Objectives

Defining objectives for sponsored research programs is further important because, quite naturally, the objectives of the sponsor and the college often are not identical. For effective and continuing relations, the objectives of the two need to be brought into harmony but not necessarily into coincidence. A difference in objectives

does not itself imply the impossibility of, or even major difficulty in, working out programs to the mutual benefit of both parties, any more than the different interests of buyer and seller in normal commercial transactions prevent the negotiation of contracts advantageous to both.

Let us enumerate some of the objectives which may influence the development of a research program. Not all will apply to each institution; some are obviously more important than others; some can be advanced openly, while others are only implied; some will be more applicable to publicly-supported institutions, and some to private colleges. If you search your mind you can add others. Here is a partial list of good and bad objectives of research programs in an engineering college.

1. Advance fundamental knowledge in both analysis and synthesis
2. Support graduate theses
3. Give financial aid to graduate students
4. Increase vitality of teaching staff, both undergraduate and graduate
5. Assist industry in the geographical area to which the educational institution owes an obligation
6. Support the military needs of the nation in research and development
7. Supply services which the intellectual resources and physical facilities of the institution are uniquely capable of providing
8. Develop additional special competencies of the institution in important technical areas
9. Increase the prestige of the institution
10. Stimulate interdisciplinary programs
11. Provide services to individual companies to place them in a better competitive position within their industry
12. Provide services to trade groups to enable them to give improved service or to compete more effectively
13. Obtain funds to support other research programs within the college or university
14. Develop better laboratory facilities for the institution and nation
15. Give staff and students experience in solving actual engineering problems
16. Obtain funds to support other educational programs
17. Keep professors happy
18. Provide supplementary remuneration for staff members as a means of competing with industry or other institutions
19. Keep up with the Joneses

Naturally the items above are not entirely distinct, and indeed may overlap considerably. So much has been said about all of them that their implications are almost obvious; some will appeal to one group, some to another, and some will even arouse feelings of revulsion and will be discarded. Some are of primary benefit to an educational institution, others to a sponsor, while many contribute to the general welfare of the nation. However, I do not have the wisdom to assure you that any one of them (even the last) should be eliminated in every college. Although some may appear to be directed selfishly toward improving the position of the educational institution, they need the open-minded consideration of the sponsor if the vigor of our colleges is to be maintained.

As has been indicated, the college objectives must necessarily be related to the needs of the sponsors. A general classification of the sponsors and

a few specific examples are given in Table I below.

It is obvious that different objectives given earlier will appeal to different types of sponsors as they are shown here. After (and only after) it has selected its objectives from a list such as appears above, each institution must negotiate with the appropriate sponsors suggested below. For example, a state university might decide it should assist the industry of its state. It should first study the needs of the state.

There may be a dominant industry with an active and progressive trade

TABLE I

CLASSIFICATION OF PRINCIPAL AVAILABLE SPONSORS FOR ENGINEERING COLLEGE RESEARCH

General Class	Sub-Class		Typical Examples
Industry	Manufacturing Companies	Large	General Electric
		Small	Company X-Hairclip Mfg.
	Utilities		Edison Research Comm.
	Trade Associations		Portland Cement
			Assn. Amer. Railroads
			Enamel Mfrs.
			Warm Air Heating
			Boiler and Radiator Mfrs.
Government	Military	General	ONR
			OOR
			OSR–ARDC
		Operating	Signal Corps
			Wright Field
			Bureau of Ships
	National Science Foundation		
	Atomic Energy Commission		
	Non-Military Service Agencies		Bur. Public Health
			National Bur. Stds.
			Public Roads
			NACA
	State and Municipal Agencies		
Nonprofit Organizations	Operating		Battelle Memorial
			Mellon Institute
	Technical Societies		
	Fund Administrations		Engineering Foundation
			Industrial Foundations
			Carnegie Foundation

association. In such a case the development of sponsorship is easy, but the institution should guard against overspecialization. If the industry of the state is diverse, it is probably better for the institution to forego the objective of direct assistance to industry and decide to devote itself primarily to a fundamental program of broad interest which can be sponsored on a national basis.

Small industries do not in general feel they are financially able to support basic research, but they can provide faculty members with valuable experience in the solution of complex practical engineering problems. On the other hand, research agencies of the Department of Defense are receptive to proposals for basic research when such programs parallel the agency objectives, and the National Science Foundation is interested *only* in basic endeavors.

Recently, because of the tax situation, some of the larger companies have been setting up their own nonprofit foundations, to which they can contribute near the end of the fiscal year when their profit position is known, and for which contributions they can receive appropriate tax deductions. This mechanism allows them to dispense grants throughout the year. After appropriate examination and consideration, each foundation selects an area in which it wishes to provide support and establishes particular objectives with which it is in sympathy. Such foundations appear to be growing in number, financial resources, and interest in engineering research or education.

Many interconnections are possible between objectives and sponsors; I leave you to explore this fertile field. I need not warn you that, just as is the case with the electron-orbits about the nucleus of an atom, there are forbidden transitions. The application of good common sense will assure an economy of effort in enlisting the support of an appropriate sponsor who will be in harmony with your objectives.

Educational Teamwork Desirable

Still another factor needs attention. It is now well recognized that in the education of engineers there must be teamwork between the college on the one hand and industrial or governmental employers on the other. The college must do what it can do best, that is, teach fundamental principles, develop the ability to tackle hard problems by basic methods of approach, and cultivate intellectual habits and abilities which will carry the engineer successfully through a career where intellectual vigor is essential. Particular examples of engineering practice taught in the university are justified only as illustrations of general principles and methods of approach.

Industry, on the other hand, must assume the major responsibility for instruction concerned with arts or "practice," with the mature development of judgment underlying particular company methods, and for education leading to increased responsibilities.

In the broad area of research it also seems desirable that a similar division of labor should be made. The engineering college should pioneer in the exploration of the fundamental areas, because this is a natural complement to its teaching functions. The development of specific "hardware" should be delegated largely to industry. An exception to the emphasis on basic

research as opposed to hardware development might be made when, as a result of work in more fundamental areas, a faculty member conceives of a new device or devices, the development of which he naturally wishes to pursue himself. Another exception must be made when, because of military needs, the brain power of the universities should be utilized without depleting these resources by transplanting them to governmental or industrial laboratories.

Interdisciplinary Projects

One of the most productive areas for engineering research lies in interdisciplinary investigations, where the resources of a university give opportunities seldom duplicated in industry. Teamwork with psychologists, physiologists, biologists, and physicians illustrate the combinations by which we can make major contributions. It should be recognized, too, that engineering is now responsible for much of the continued development of what has been referred to as the fields covered by classical physics.

One of the most serious problems that have arisen, largely as a result of sponsored research, is the arbitrary division which is common in many of our colleges between the research and teaching functions and staff. This has probably been the result of historical development and economic forces. At the turn of the century, engineering colleges had research functions and operations quite similar to those of the Colleges of Liberal Arts, where each professor was expected to, and generally did, do a certain amount of research as a supplement to his teaching. At that time, costs of equipment were moderate, and the laboratory facilities used in teaching were generally adequate to support the relatively simple research needs of the day. As costs began to increase, however, a teacher who wished to do research often had to spend as much time selecting a project whose equipment needs were simple, as he did to the investigation itself.

Two solutions to this problem developed slowly for several decades before World War II:

1. Engineering Experiment Stations emerged, largely in state institutions, with specific budgets covering both personnel and equipment for long term efforts, and
2. Sponsored research expanded steadily, also with specific budgets, but normally of limited time duration.

The concept of the Experiment Stations was largely one of service to the geographical area supporting the institution, and there was some urgency to produce results which would be recognized by and generate support from the political body supplying the funds. In contrast, sponsored research was largely supported by industry. Funds from individual companies were usually applied to the solution of specific problems. Again there was a sense of urgency which prevented the laying of a broad foundation of fundamental knowledge. The trade associations which began to come into the field, on the other hand, were often interested in longer range developments and also in finding particular individuals who would devote most, if not all of their time to the interests of the supporting agency.

These appear to have been the major sources of support for engineering research in colleges before World War II; even then the funds available were very limited. Concurrently, the larger

industrial organizations were building up research organizations of their own, devoted primarily to the search for new products, but also at times supporting fundamental research which produced results of importance, in general outstripping those of the engineering colleges.

Examples of such basic research were the Davisson-Germer experiment at the Bell Telephone Laboratories, which gave experimental confirmation to the wave nature of electrons, and the work of Langmuir at General Electric in such diverse fields as electron emission, soap films, and cloud seeding. Under these conditions, many college professors who were not supported for a major portion of their time by Experiment Stations or industrially-sponsored programs became discouraged. They doubted the possibility of doing anything really effective, and devoted themselves exclusively to teaching, allowing their research abilities to atrophy.

Thus all the means developed for research support tended to separate the functions of teaching and research in the engineering colleges, a development which did not occur in the arts or pure sciences. We seem to have justified the statement that we never get a final solution to our problems; we can only hope for a relief from the last solution.

During World War II, military demands required the development of new research centers to solve not only the scientific, but also the engineering problems involved in the search for new and improved weapons. When teaching needs were reduced, and funds for research were unlimited, the professors of the country represented a personnel depository which could be used to meet our expanded research and development requirements. Under these conditions two things happened, and we might as well admit them:

1. The new research organizations set up in educational institutions to do creative engineering work were largely manned and almost entirely directed by physicists who, in the previous decades, had combined teaching with fundamental research.

2. Engineering teachers took leaves from the universities and went into industrial research under the direction of experienced administrators.

Frankly, I do not think that engineering education was ready for the leadership which it had the opportunity—but not the preparation—to assume.

Following the War, the Congress and government agencies recognized the need for the greatly expanded research program necessary to preserve our way of life. Again, as larger sums became available, and as manpower remained in short supply, there was a tendency to return to the old system of division into

1. A staff largely responsible for teaching, and

2. A separate staff for research, with some limited responsibilities in graduate teaching.

I believe the major problem of the next decade is that of finding out how to use sponsorship of research by both governmental and industrial organizations to develop an integrated program of research and teaching in which each effort supports the other. Perhaps to do this we need a broader definition of "research" in the engineering field. For example, at Illinois we have a program in which the engi-

neering college is actively developing improved teaching of mathematics at the high school level. I consider that the individuals participating in this program are definitely active in research—a research effort which we hope will attract industrial support because of its overall importance to industry. Of course, we must recognize that some professors can make their major contribution in teaching, while others make it in research. I hope that more members of engineering faculties will combine teaching with research, so that they do not identify themselves as either teachers purely or research workers solely.

Freedom in Research

One of the major attractions in an academic life has been the freedom to select one's own work. A university professor comes closer to being his own boss than any other individual. He normally chooses his general area of teaching, and, aside from meeting his classes, directs most of his own working hours. This is not a responsibility which can be entrusted to the lazy, so laziness is a major crime for a professor, a violation of trust which cannot be condoned.

There is some danger that, in accepting research contracts, we may feel it necessary to bring into the atmosphere of the university a miniature model of industrial organization, which, even if it does not include time clocks, introduces the time-clock attitude. This should be guarded against as the plague. Particularly, there should not be one set of rules for the teaching staff and another for the research staff, or their separation becomes automatic. This is not an easy problem to solve, especially because research programs involve extensive use of mechanics, stenographers, and other workers who must, or wish to, observe time schedules.

Research laboratories in industry are devoting serious attention to the problems of developing an atmosphere more like that of academic institutions. Let us not lose one of our major assets by slipping in the opposite direction and becoming too industry-like ourselves. For example, any sponsored research (other than military) which limits the right of a professor to publish should certainly be questioned seriously.

Furthermore, I do not believe it desirable to go out and secure a project and then come back and look for a professor to conduct it, or worse yet, assign a staff member to direct it. The initial formulation of the research program should start with the professor and the educational institution, not with the sponsor.

Solving our problems will require careful interpretation of them to our sponsors and potential sponsors, both industrial and governmental. It will also require more emphasis on certain objectives and the elimination of others. I will leave you individually to select those objectives you deem most important for your own institution, and to develop harmonious relations with sponsors which will further those objectives.

VEREIN DEUTSCHER INGENIEURE CENTENARY CELEBRATION

Program May 12-15, 1956, Berlin, Germany

Saturday, May 12

Addresses on: The relations of natural science and technology
Technological trends

RESEARCH AND DEVELOPMENT:

Power problems, with particular emphasis on atomic fission
Influence of the material on the development of processing techniques

DESIGN AND CONSTRUCTION:

The experiment as a basis for the design
Lightweight construction
Beauty of form

Sunday, May 13

Formal address on: Man and his technology
Festival performance in the "Schiller-theatre"

Monday, May 14

Addresses on: Social effects of technology
The law of survival

MANUFACTURE:

Principles of fabrication
Materials handling

MAN AND ECONOMY:

Future leadership
The engineer and the distribution of goods
Industrial legal protection

EXTRA-CURRICULAR ACTIVITIES FOR PROFESSIONAL DEVELOPMENT

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Worcester, Massachusetts

Extra-curricular activities can be a valuable adjunct to the formal educational process. Although this conclusion has been and will be challenged by many educators, evidence will be offered to support it. The positive contribution of a well-balanced and well-rounded program of extra-curricular activities to the professional development of engineering students has neither been fully recognized nor exploited. Surveys reveal that many graduates of engineering colleges are promoted to managerial positions.

This prompts a question: Does the average engineering curriculum adequately prepare these young men for managerial positions? The answer generally is "no." Obviously, technical competence is not synonomous with managerial competence. Various management courses are offered at some engineering colleges, but these courses suffer from two limitations. First, only a limited amount of time can be devoted to such courses in an engineering curriculum. Second, no matter how realistically presented, such courses are still academic. Relatively little practical experience in dealing with people can be gained in the classroom. To a limited extent, however, this experience *can* be gained through a program of extra-curricular activities in which most students participate.

In presenting the case for extra-curricular activities one often encounters the argument that extra-curricular activities reduce the amount of time students can devote to their studies. It is well to call to mind the old proverb "All work and no play makes Jack a dull boy." Psychological investigations have demonstrated that a break from studies providing a little relaxation can lead to more efficient functioning of the mind. Furthermore, the time students would devote to a well-balanced program of extra-curricular activities often has been wasted in the past by "shooting the breeze," seeing movies, or drinking coffee. Many more students could participate in extra-curricular activities without reducing their study time by spending less time in "bull sessions."

Managerial Skills

A few of the more important managerial skills that can be acquired and sharpened by participation in extra-sharpened by participation in extracurricular activities are covered below:

1. *Cooperation.* The importance of the ability to cooperate and work with others cannot be overestimated. Successful management is based upon cooperation. Without it no organization can function effectively. A man will not be a successful manager unless he knows people and also their

idiosyncrasies. Experience in cooperation and working with others gained through extra-curricular activities can prove valuable when one moves into both the managerial and professional ranks. Perhaps this is the greatest value of extra-curricular activities.

2. *Initiative.* The most successful engineers and managers are men with initiative. They are the ones who inaugurate new programs or create new policies. Our economic system is generally competitive. Each business firm is attempting to get the jump on its competitors. Each firm is seeking men with ideas—with initiative. Extra-curricular activities require initiative on the part of the students. New ideas, new courses of action for the yearbook, debates, or dances are thought up and implemented each year.

3. *Leadership.* There is no substitute for experience. This is particularly true in the case of leadership. Extra-curricular activities provide an excellent training ground for leadership. Young executives customarily are urged or required to participate in community affairs. Charity campaigns, youth movements, church work, service club leadership, public affairs and civic speaking engagements are activities that most young men moving into managerial ranks are pressed to join. Where else in college, other than in extra-curricular activities, do students have the opportunity to gain leadership experience? Such experience is seldom available in the classroom.

4. *Decisiveness.* Decisiveness is another key characteristic of the good manager. Extra-curricular activities provide opportunities for students to gain experience in decision-making. To increase this value, however, the administrations of some of our colleges must recognize the maturity of their students and give them a freer hand in running student organizations. Often students are not permitted to take the initiative in running their organizations or are not allowed to make decisions that they, rather than the administration, should make. After graduation, students will not have college administrators readily available to make or deny decisions for them. Decisiveness is a trait lacking in many managers. Students cannot be expected to develop and sharpen this managerial skill unless they are afforded the opportunity by the administration of the college.

5. *Judgment.* Closely related to decisiveness is judgment as to people and situations. Successful men usually attribute their success to good judgment. Competent managers are able to "size up" other men as well as situations. They use good judgment in hiring and assigning employees. Sound judgment is essential to the success of a business firm in our competitive society. Should a new product be introduced? If so, when? Should plant expansion be undertaken? Should Jones be transferred or promoted? These are typical of the questions that require careful consideration. The opportunities which extra-curricular activities afford students to exercise this kind of talent are many.

6. *Effective Expression.* Engineers are notoriously poor at expressing themselves, either orally or in writing. The number of technical writers employed in industry and the number of communications courses incorporated in training programs for young engineers employed by large corporations are proofs of this charge. Opportunities are afforded by extra-curricular

activities to develop and practice effective speech and writing. Campus newspapers and yearbooks offer rare opportunities for students who have trouble writing effectively.

7. *Character Development.* This is an intangible, but of greatest importance. A sense of responsibility and an elevated code of values can be engendered through extra-curricular activities as well as in the classroom. Unfortunately, character development too often is neglected. All too commonly, students fix their sights solely on the material things of life. Unless they realize there is more to life than material things, they are in for keen disappointment later on. Also, our society will suffer if many of our young men, who in the near future will be leaders, are materialistic-minded, or fail to develop their ethical and spiritual sides.

Conclusions

In this light, extra-curricular activities must be acknowledged to be a part of the educational process rather than a parasite sapping its energy. Extra-curricular activities are supplementary to the formal educational process and can contribute positively to the professional development of engineering students by fulfilling many of the demands of industry without reducing the amount of curriculum time devoted to engineering subjects. Industry demands young men who are effective speakers and writers and possess the ability to work with others. Employers demand men who display initiative, leadership ability, decisiveness, sound judgment, and excellent character. If an attempt were made to develop these qualities by academic work, little time would be available for engineering subjects; extra-curricular activities are an economical means of meeting this requirement without impairing curricular strength.

In conclusion, it is worth noting that only a small percentage of engineering students participate in extra-curricular activities. These often are the students who, from the standpoint of professional development, perhaps have the least need to participate—either because they have done so before or have special abilities in the administrative areas. To a limited extent, therefore, students should be encouraged to participate in extra-curricular activities. This may necessitate the expansion of the number and types of extra-curricular activities at many engineering colleges.

ENGINEERING SOCIETIES DIRECTORY

On behalf of its constituent and associate groups, the Engineers Joint Council will publish this summer the *Engineering Societies Directory,* listing all local, regional, and national engineering societies. Included will be the name and purpose of each organization. Revisions will appear periodically. Publication price is $3.50, and orders should be sent to E. Paul Lange, EJC Secretary, 29 West 39th Street, New York 18, New York.

THE NEED FOR MORE "KNOW WHY"

JESS H. DAVIS

President, Stevens Institute of Technology
Hoboken, New Jersey

The vast and continuing increase in our understanding of physical phenomena in the past 15 years, as well as our ability to put this knowledge to work, has grown more than most of us realize. There are two ways of dealing with this great abundance of both new and classical knowledge in teaching young men to become good, useful engineers.

The first is the route the Russians have already taken. In Russia, the recognized engineering fields have been divided and subdivided, then the sub-divisions have been subdivided. A Russian engineering undergraduate is assigned to study in one of those many sub-sub-divisions. Each man is trained in a very limited field. When he graduates he is assigned to his lonely little slot, doing exactly what he was trained for and nothing else. From the kind of super-specialized training he gets, the Russian engineering student probably would find it difficult to move out of his slot—even if he dared to do so.

As a major step in increasing their industrial and war potential, the Soviets have greatly increased the number of their engineering colleges and the total engineering enrollment. There are estimated to be some 300,000 students in Soviet engineering schools as against our 150,000, and the margin is growing larger each year. The reason is obvious: if you are going to insist on specialists of very limited scope, you are going to need a great variety of them to cover the entire spectrum. To get high industrial production, you must have them in depth.

The Russians last year graduated 53,000 engineers to our 22,500. Obviously, we are not going to match the Soviets in numbers for a while yet, even if we should be able to treble our engineering school enrollment overnight. Our only hope of meeting this potential threat to our security and to our industrial leadership, it seems to me, is to put our emphasis on *quality*. By that I mean taking just the opposite tack from that of the Russians. Instead of trying to educate specialists who are good only in a limited field of engineering, let's throw away the blinders and let American engineering students see more of *all* the fields. Let us help them also to gain a better understanding of the relationship of each of the fields to the others.

Specialization is an integral part of industrialization. But if we hope to keep our free, industrial society supreme, our engineers and scientists must be men with greater breadth of view and the adaptability to make use of engineering knowledge in many fields, instead of a tiny corner of a single field. The bio-chemist and the bio-physicist, the physical metallurgist,

the physical chemist as well as the chemical physicist, show by their very titles how the fences are disappearing in science and engineering as we come to recognize more fully the universality of scientific truths. The engineering leader of the future must be at home in many branches of his calling if he hopes to help us reap the benefits that new scientific and engineering concepts make possible. The century ahead in science and in engineering belongs not to the specialist, but rather to the synthesist who can fit together many disparate truths and create a new truth.

The engineering undergraduate of the future will have to learn more of science, more of the engineering principles and, unfortunately perhaps, less of the practical applications. There will be fewer undergraduate classes in air-conditioning and more in thermodynamics, fewer in hydraulic turbines and more in fluid dynamics. There will be less design work of an empirical nature but a deeper study of mathematics and of the physical and engineering sciences where the principles of all designs originate. If we are to keep ahead of the world, there must be fewer engineering vocational schools and more engineering academies.

Engineers in industry are expert in converting new scientific discoveries to practical use and they are doing it at a rapid rate, as our advances in automation, electronics and nuclear devices illustrate. Researchers in our colleges, of course, also contribute, but industry itself is a much vaster and better-stocked laboratory for the development of the practical applications of science. By the same token, industry can and is doing a much better job than the colleges of teaching the "how-to-do-it" techniques which the new engineering graduate in industry must know. What the colleges can do best is to teach not the "hows" but the "whys" of the physical and engineering sciences. With this knowledge as a base, the new engineering graduate is a far more apt pupil in learning "how-to-do-it" techniques in the company or industry he joins.

As you know, a number of our larger industrial firms already have extensive programs for teaching engineering techniques peculiar to their own businesses. I believe these firms will continue to expand their programs and that other companies will start training programs of their own. Eventually industry will teach a major portion of the engineering applications of science, leaving it to the engineering colleges to concentrate on improving the undergraduate's understanding of the theoretical concepts on which the applications are based. I see no other way of enabling a student to cope with the new knowledge that keeps piling up in such awesome proportions.

What I am leading to is this: We have heard it said many times that it was the "know-how" of American industry that enabled us to overcome the enemy in the last shooting war. But, if American industry is going to keep ahead of the new enemy, its engineers must combine with their "know-how" a "know-why"—a broader, deeper knowledge of the laws of science and engineering and how those laws are put to use. Only by this "know-why" can we hit upon the new and startling inventions that will keep us ahead of the Soviets and their over-specialized technologists. More "know-why" will bring about the startling new "break-

throughs" that will open bright new opportunities like those brought on by the vacuum tube, the airplane, and the electron microscope.

I am glad to say that other engineering educators are thinking along these same lines. The Committee on Evaluation of Engineering Education of the American Society for Engineering Education recently made recommendations to the engineering colleges that they move to strengthen their undergraduate programs in the basic engineering sciences and make them a common core of all their engineering curricula. I feel sure that these recommendations will be incorporated in the curricula of all accredited engineering institutions within the next five years. That will mean that more of our colleges will have to weed out more and more of their "how-to-do-it" courses and I for one say, "good riddance."

NSF OFFERS GRANTS TO ATTEND BRUSSELS APPLIED MECHANICS CONFERENCE

The National Science Foundation is planning to assist a limited number of engineers and scientists in attending the ninth International Congress of Applied Mechanics in Brussels, Belgium, from September 5 to 13, 1956. Applications for these international travel grants should be submitted to the National Science Foundation, Washington 25, D. C., not later than August 1, 1956.

NSF AIDS 1957 SUMMER INSTITUTES

To encourage a greater number of Summer Institutes for high school and college science teachers in 1957, the National Science Foundation will offer Institute participants financial support of approximately seventy-five dollars per week plus fifteen dollars per week for each dependent. Colleges and other institutions which are planning Summer Institutes should submit their proposals to the NSF by September 1, 1956. Those proposing approved programs will receive funds that are to be used to sponsor Institute participants. Details can be obtained from Harry C. Kelly, Assistant Director for Scientific Personnel & Education, National Science Foundation, Washington 25, D. C.

THE FUTURE OF LIBERAL SCIENTIFIC EDUCATION

Excerpts from an Address
January 4, 1956, New York City

DR. JAMES R. KILLIAN, JR.

President, Massachusetts Institute of Technology
Cambridge, Massachusetts

". . . An institute of technology stands today in the main current of contemporary life, generating the discoveries and ideas, and educating the kind of men which shape our industrial society. The scientist, the engineer, and the manager are among the chief architects of our flourishing technological society, and their responsibility grows steadily greater for its state of health and for its advancement. The professional competence and insight expected of the scientist and engineer, and their understanding of the social forces they affect and are influenced by, all become greater as our society becomes more complex and as our nation assumes greater responsibility and faces greater hazards. . . ."

"With technology playing an important role in our national life, our institutions where science, engineering, and management are taught have a correspondingly important role to play and must as a consequence be closely meshed with both the immediate and long-term needs of our society. In a period of manpower scarcity they must accept additional educational responsibilities in order to augment our scientific manpower resources—responsibilities which require enhancing quality while increasing numbers. In a period of cold war they have a uniquely specialized part in the technology of survival—the survival of ourselves and of the free world.

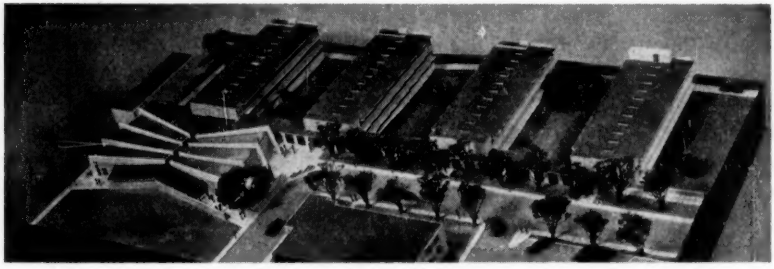
"They have a responsibility to further our basic science and to achieve those subtle environmental conditions where the creative mind flourishes best. In a period when society vests a growing responsibility in scientist and engineer, these educational institutions have the responsibility of educating professional men so that they can both advance their specialties and at the same time play an important role as perceptive, broadgauged citizens contributing to the common account. To do this, these institutions must achieve new working coalitions of the sciences, the social sciences, and the humanities.

"Our institutions of technology may well be leading the way to a liberalized liberal education that is relevant to the needs of modern man and of modern technological society. A superb opportunity exists to provide a new type of liberal education polarized about science and given new coherence and standards by professional requirements. In our institutions of technology there is a vision of a new kind of indigenous American university built around science and social technology but embracing the arts, the social sciences, and the humanities as essential and equal partners in its

corporate aims and culture. The liberal arts cannot fulfill their responsibilities if scientists and engineers lack the humanistic quality once ascribed to the Athenians—the art of making gentle the life of mankind. Our great schools of science and engineering have a special responsibility today to develop new bridges interconnecting the sciences, the social sciences, and the humanities, to reduce the protective tariffs of intellectual vested interests, and thus to achieve a liberal education that is liberal in the deepest sense for our American civilization."

COLORADO A & M PLANS NEW ENGINEERING CENTER

One of the first groups of buildings to be planned by Colorado Agricultural and Mechanical College under its new program authorized by the last session of the Legislature will be an integrated unit for the School of Engineering. As shown below, the new Center will consist of three three-story structures connected by an arcade. A fourth building, matching those for engineering, will be devoted to work in physics, and an adjoining lecture hall will seat 300. Each of the wings will have laboratories of one department on the first floor, but other facilities for classes and drafting will be used in common. Construction is to be completed by the fall of 1957, when all departments will move to the new center; a capacity enrollment of 800 students is expected for the following session.



IN THE NEWS

Rensselaer Receives Grant for Architecture Lectures

Rensselaer Polytechnic Institute recently received from the Aluminum Company of America Foundation a grant of $2,500 to inaugurate a series of lectures by eminent architects and outstanding authorities in allied fields. Students will thus be given a better acquaintance with the leaders in the field of architecture, and the R.P.I. architectural program will benefit from the fresh points of view presented.

Cornell Offers Industrial Engineering Seminars

The Sibley School of Mechanical Engineering, Cornell University, will offer its Annual Industrial Engineering Seminars from June 12 through June 15. The series will be concerned with Industrial Management, Manufacturing Engineering, Small Plant Management, Methods Engineering, Applied Industrial Statistics, and Industrial Marketing. Discussion leaders and speakers will include specialists from both industry and the Cornell staff. Additional information can be obtained from Andrew Schultz, Jr., Department of Industrial and Engineering Administration, Cornell University, Ithaca, New York.

Law and Industrial Engineering at University of Tennessee

A new curriculum combining law and industrial engineering has been announced by the University of Tennessee, Knoxville. Without losing credits towards his engineering degree, a senior industrial engineering student may take law courses to test his ability and interest in the field. If he likes the arrangement, he continues his joint work the fifth year, receiving his engineering degree. Then he adds a sixth year-and-a-quarter to obtain his law degree. The program is designed to save time for students who wish to fill management positions requiring legal training.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

JOHN L. ARTLEY, Chairman
Duke University

HAROLD A. FOECKE, Editor
University of Notre Dame

THE UNCONSCIOUS ART

LEE HARRISBERGER

Assistant Professor of Mechanical Engineering
North Carolina State College, Raleigh

This is about the time of year that, for the new teacher, means the end of a pretty hectic session. As a matter of fact, he's glad it's about over, for he probably has a feeling that he was the only one in class that learned anything. The only consolation he has is a chance to do better next fall.

Most of us who have been teaching more than a couple of years are likely to forget what a difficult time it was for us. We never stop to realize how much we've learned about the art of teaching. We rarely give much thought to how we teach our classes; it's just a matter of deciding what material we're going to cover, planning lectures and assignments, writing tests and letting it go at that.

Actually, skill as a teacher is attained almost unconsciously. It would be hard to tell a new instructor exactly how to teach his first class. Oh, we could tell him how to plan his schedule and cover the material—but could we define or outline the subtle moves involved in the human relations of teacher and student?

A new teacher is faced with two devastating conditions when he enters his first engineering class: First, he possesses a demoralizing lack of confidence in his knowledge of the course and what to do about it. Second, students can smell a neophyte a mile away and will inevitably set out to give him a "hard time." After all, most of the students' classroom experience was gained under the "old hands." Now they're cocky enough to think they can match a new man in a duel of wits. Students take delight in attempting to skewer a young instructor to his blackboard and then leave him dangling helplessly on an intellectual impasse.

For the first year, at least, the instructor faces constant challenges—questions he has never thought of before, problems he has never worked, students who buck his system and attack his statements, his grading, solutions, methods, fairness, and answers.

After you've been teaching a while you never seem to have such troubles. There are few problems; the students

take an interest in the course and seem to respond well. There are no embarrassing impasses. If a young teacher should ask how you would handle a situation like this or that, you're somewhat surprised; you never have anything like that happen any more. I suspect we'd have to lean back, stare at the ceiling for a minute and say, "Just what would I do if that happened in my class?"

What, then, makes up this unconscious art of teaching? Generally, we develop a capacity to sense the student or class reaction and take advantage of it or head it off. We learn what will arouse interest and what won't. But above all, we have learned we're teaching *students* instead of thermo or mechanics.

As experience grows, we put more effort into teaching the student than into covering the material. Our lectures take on more color, include more sidelights, less technique and detail. We try to motivate the student, to challenge his curiosity and enthusiasm. We finally learn how to put the burden back on the student, where it belongs. We decide what is important in the course, show the student the way, then follow him and keep encouraging him forward. Instead of racing across the board in a cloud of derivations and arriving triumphant at the solution only to find we're the only one there, we begin to learn it's not what WE know that counts, but what *they* know.

These are the things we've learned to do—but we can't exactly put into words how we do them. We're apt to say, "Well, it depends on how things are going."

If you are a new teacher just finishing up your first semester or year, take heart. You would be surprised to know how much you've learned about the unconscious art of teaching. Just watch how much better next fall will be. Keep these things in mind and you'll find you'll soon become a teaching addict.

You can't *show* them a thing—they remember very little of what they see done, and can rarely duplicate it.

They learn what they do for themselves, by themselves.

Your only purpose is to make the subject so interesting and challenging they will "eat it up."

Be fair and humble; never be afraid to admit you're wrong or don't know. But try to find out before next class.

Notice that these injunctions have nothing to do with what you teach. What counts is how you go about it. No one can tell you exactly how to teach; it's the unconscious art developed by being conscious that you're *teaching—not* lecturing.

DIRECTORY REVISION PLANNED

Preliminary correction of the ASEE membership lists for the 1957 Yearbook issue is now in process, and type changes will be made as of July 15, or as soon thereafter as possible. Please check your listings and inform the Editorial Office if revision is indicated. For those who are moving this fall, a final postcard inquiry will be sent later to all members, returnable by October 15.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Division of Engineering Drawing
Editor: Albert Jorgensen, University of Pennsylvania

A GRAPHICS COURSE FOR SCIENCE MAJORS

EUGENE PARÉ

Illinois Institute of Technology, Chicago

A paper presented at the Midwinter Meeting of the Drawing Division, Chicago, January 27, 1956.

A few years ago our department was asked to develop a basic drawing course for students majoring in chemistry, mathematics, and physics. Consultation with the interested departments revealed that something different from our standard offering for engineering students was desired. A broader course that contained less specialization in the instrumental drafting of machine parts, and which would promote better freehand graphical presentations in scientific reports, was requested. At the same time it was essential that we retain most of our training in orthographic visualization, because the science students were expected to have a solid foundation for blueprint-reading.

Fresh View

Generally, a fresh point of view was required rather than a change in topics. For instance, problems in geometric construction and basic orthographic projection were just as well selected from chemistry and physics as from mechanical engineering. Freehand execution in many cases replaced the instrumental technique.

Some new topics were added, however, including:

1. Use of mechanical lettering devices.
2. Title design for laboratory reports.
3. Preparation of bar graphs, line graphs, rate-of-change graphs, percentage charts, and organization charts.
4. Graphical mathematics, including curve plotting, roots of equations, solutions of simultaneous equations, periodic functions, development of empirical equations, vectors, and introduction to nomography.

These innovations represented a thirty per cent addition to our program, so it was necessary to make substantial cuts in the traditional material. The time previously devoted to dimensioning, screw threads and fasteners, and production of working drawings was, therefore, drastically reduced. The student was introduced to these curtailed topics through the medium of problems which required blueprint-reading.

Order of Topics

The order of topics for the entire course is as follows:

Evolution of graphical representation. In our introductory lecture, we trace the historical development of drawing as a means of communication. We discuss the accumulated wealth of man's experience and knowledge leading to the development of Monge's system of orthographic projection. Reference is made to drafting standards and the necessity for continual revision to keep in step with industrial advances.

Mechanics of freehand and instrumental drawing. Particular emphasis is placed on freehand execution. The student is given instructional assistance while acquiring this technique. Similarities between freehand lettering and freehand drafting are considered.

Freehand lettering and mechanical lettering devices. Each student is required to purchase the relatively inexpensive Doric lettering tool, and about sixty per cent of the lettering in the course is performed with this mechanical lettering aid.

Title design for reports. The student is not presented with a set of rigid rules for titles, but rather is encouraged to experiment with original patterns of his own, particularly in the area of non-symmetrical design.

Use of measuring equipment. As we are concerned with science students, a good deal of attention is directed to the metric and American decimal systems.

Graphic constructions. Under this topic, problems have been obtained that involve such pertinent equipment as the Centigrade and Fahrenheit thermometers, laboratory standards, electric cell, ammeter, centrifuge, Erllenmeyer flask, thistle tube, and pulley systems. In this connection, we find that we are dealing not only with graphic representation, but with physics as well.

Charts and graphs. The student is introduced to the use of colored pencils for both lines and shading. Problems are presented in which the student deals with the electro-chemical equivalents of selected elements.

Orthographic drawing. This topic includes selection of views, orthographic reading, and sectioning.

Primary Auxiliaries. Under these topics, dealing directly with orthographic projection, we are more concerned with the student's ability to visualize than with his drafting proficiency.

Pictorials. Isometric and oblique are both formally presented, although the students have been introduced to pictorial sketching earlier in the course. Some basic concepts of line and smudge rendering are also discussed.

Graphical mathematics. We deal with the accurate plotting and significance of equations, graphical intercepts, simultaneous equations, use of rectangular coordinate and logarithmic paper for the production of empirical equations, the graphical addition and subtraction of periodic functions, alignment diagrams, dimensioning analysis, and blueprint-reading.

Elements of design. I believe we have devised a final project that could well be employed in any basic drawing course. The student is provided with a blueprint of a vise base, complete with detail specifications for screw threads and limit dimensions.

To find answers for many of the questions presented in this problem,

the student finds it necessary to utilize a textbook for reference. He must, for the first time, discover the meaning of a thread note; he must indicate the tolerances for both fractional and limit dimensions. In all, some fifteen questions based on the drawing provide a measure of the student's ability to visualize, and at the same time the print introduces several new features of industrial drawings.

After this blueprint-reading portion of the assignment has been completed, the student is confronted with an original design project of his own. Using the given vise base as a control, he is asked to create the design for a suitable sliding jaw to work with the base. The drawing is done freehand, but is presented complete with dimensions and other specifications. The student is left pretty much to his own devices, and as you can well realize, he again finds his textbook a valuable reference.

Interesting to Teach

The course has been an interesting one to teach. Apparently it has been equally stimulating to the student; after completing the course, three of our current science majors transferred to our teacher-training program in drawing.

In teaching methods, several alterations were made that helped to conserve time and improve presentation. The descriptive geometry approach was introduced early in the course and treated as a method of visualization throughout the semester. Problem-solving was utilized more as an instructional aid than as a device for measuring drafting skills. About forty per cent of the laboratory time was devoted to practice problems. Some were solved by the entire class as part of a blackboard presentation. Others were separate problems distributed according to student abilities with the solutions discussed on completion. By this recognition of individual differences, the skill in visualization of the slower student developed, and at the same time the more adept student was presented with more challenging material.

Re-Orients Concepts

The development of this course has been a valuable addition to our departmental offerings. It has, I am sure, been of even greater significance to me as a teacher, for it has served to re-orient some of my basic concepts on the teaching of drawing. It has stimulated my interest in experimenting with different teaching methods and has caused me to question traditional course content.

In general, I believe that we as drawing teachers are hesitant about experimentation, for we have always been rather proud of uniformity. We have developed or purchased expensive films and other visual aids which we hesitate to set aside even for a semester. We have accumulated a collection of good problem material which we religiously employ year after year. We are reluctant to change that which has served us well, but our devotion to the traditional tends to impede rather than encourage our progress.

Perhaps we ourselves should take the initiative in the development of simplified drafting methods, rather than just offer resistance to such experiments by industrial leaders. Perhaps we should concentrate less effort on formal problem-solving and devote

more time to other instructional methods. Perhaps we should not strive for such a high degree of drafting proficiency, but rather utilize the time to introduce broader concepts of graphical representation. We might teach the economics of dimensioning rather than the technique of size-description. We could introduce some aspects of the geometry of design rather than the formal execution of working drawings.

Experiment!

Might it not be wiser if we reduced handbook drafting (such as the representation of screw threads, springs and fasteners) and apply the time saved to a more thorough treatment of the theory of projection? Yes, there are many things we can do. But whatever we do, let us not be content with the status quo; let us set aside the traditional—let us experiment!

WEBER ACTING PRESIDENT

Dr. Paul Weber, a member of the ASEE since 1944 and Dean of Faculties at the Georgia Institute of Technology, has been named Acting President of the Institute until a successor to the late Dr. Blake R. Van Leer is appointed. At Georgia Tech since 1927, Dr. Weber had served as professor of chemcial engineering and Director of the School of Chemical Engineering until he was appointed Dean on July 1, 1955.

ROYS APPOINTED VICE PRESIDENT

Dr. Francis W. Roys, a member of the ASEE since 1925, has been appointed Vice President of Worcester Polytechnic Institute, effective April 1, 1956. Dr. Roys, who is Chairman of the WPI faculty as well as Dean of Engineering, has been associated with the college since his graduation there in 1909. From 1923 to 1949, he served as head of the mechanical engineering department. He became Dean of Engineering in 1939 and Dean of Students in 1954. He will continue as Dean of Engineering.

CRONVICH TULANE DEAN

Member of the ASEE since 1950, James A. Cronvich, professor of electrical engineering at Tulane University, has been appointed Dean of the department of electrical engineering in the Tulane School of Engineering. He will succeed C. W. Ricker, a member of the Society since 1921, who will retire June 30 after serving for 28 years as member of the Tulane engineering faculty.

TEACHING POSITIONS AVAILABLE

MECHANICAL ENGINEER NEEDED AS Associate Professor or Professor and Department Head. Fields of Machine Design, Air Conditioning, Heating, and Ventilation preferred. Department has recently moved into new building and is equipping new laboratories. Housing available at reduced rates. Location, South. MAY-3.

ELECTRICAL, MECHANICAL, CHEMical Engineering, and also Mathematics and Physics staff openings. Industrial experience desirable. Opportunity for research. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Massachusetts.

CHRYSLER INSTITUTE OF ENGINEERing again has openings on its full-time teaching staff. For: supervisor of engineering graduates working on individual automotive design projects as a part of their Graduate School course. Duties would also include supervision of graduate classwork. Desired qualifications are age 25–40; B.S. degree or higher in engineering; at least 2 years of college teaching experience; some design experience, preferably automotive. Also a teacher and supervisor of Graduate School classwork. Qualifications are age 25–40; M.S. degree in engineering; experience in teaching Mechanical Engineering subjects. Write to Chrysler Institute of Engineering, Att: L. R. Baker, Director, P. O. Box 1118, Detroit 31, Michigan.

ASSISTANT PROFESSOR OR INSTRUCtor to teach fundamental heat power and related fields. Compensation dependent on qualifications. Long established college, high professional reputation. Graduate Study opportunities available. Location, New York City. Appointment to start September, 1956. Send resumé. MAY-1.

ASSOCIATE PROFESSOR, ASSISTANT Professor, or Instructor, (rank and salary determined by training and experience) to teach courses in the Petroleum Production Option. Teaching period nine months. Opening, September 1, 1956. Location, Southwest. MAY-2.

MECHANICAL ENGINEERING POSItion to teach undergraduate courses in thermo-fluids and heat transfer. M.S. preferred. Opportunities for graduate study, industrial consulting, and research. Rank and salary open. Start September, 1956. University of Santa Clara, California.

ASSISTANT PROFESSOR AND INstructor in mechanical engineering, beginning September 1, 1956. M.S. degree or equivalent. One applicant should be qualified to teach basic thermodynamics and heat power courses, the other kinematics, and machine design, together with heat power laboratory. Salaries commensurate with qualifications. Apply to Professor W. M. Richtmann, Head, Department of Mechanical Engineering. Colorado School of Mines, Golden, Colorado.

ELECTRICAL ENGINEERING PH.D. needed for teaching and research. Also Instructor for same duties; B.S. degree acceptable if willing to work toward M.S. Salaries commensurate with qualifications. Write Head, Department of Electrical Engineering, University of Denver, Denver 10, Colorado.

ELECTRICAL AND MECHANICAL ENgineering Associate and Assistant Professors and Instructors needed. Permanent opportunities in expanding programs. M.S. degree desirable. Fellowships available for part-time graduate work in state university at M.S. level. Please forward complete details of education, practical experience, and personal background to Dean of Engineering, Milwaukee School of Engineering, Milwaukee, Wisconsin.

ASSOCIATE, ASSISTANT, PROFESSOR or Instructor, rank dependent upon training and experience, to teach basic mechanical engineering courses. Machine design experience preferred. M.S. degree or teaching experience desirable. Position available September 1, 1956. Write to Head, Department of Mechanical Engineering, South Dakota State College, State College Station, Brookings, S. D.

MECHANICAL OR INDUSTRIAL ENGINEER with B. S. degree as Assistant Professor to teach manufacturing processes and to be in responsible charge of all machine laboratories. Position starts September, 1956. Salary on nine months basis. Write to Chairman of Mechanical Engineering Department, University of Delaware, Newark, Delaware,

ASSISTANT PROFESSOR OR INSTRUCTOR needed in electrical engineering, beginning September, 1956. Must be qualified and interested in teaching basic undergraduate courses plus one graduate course. Ph.D. or M.S. required, with salary dependent on qualifications. City location with many industrial contacts. Apply to Department of Electrical Engineering, Saint Louis University, St. Louis 8, Mo.

ENGINEERING DRAWING AND DESCRIPTIVE geometry position open. Engineering degree necessary. Opportunity to do graduate work. Rank and salary dependent upon applicant's education and experience. Send inquiries to E. J. Marmo, Professor and Chairman of the Department of Engineering Mechanics, University of Nebraska, Lincoln, Nebraska.

ELECTRICAL ENGINEERING TEACHING-research positions available at Assistant and Associate Professor level for graduate and undergraduate courses in communications, circuits, and computers. Ph.D. desirable, M.S. essential. Appointments to begin September, 1956. Apply to Professor Joseph C. Michalowicz, Catholic University of America, Washington 17, D. C.

CONTINUATION OF EXECUTIVE BOARD MINUTES

From page 813; for beginning of report, please see page 807.

19. *AAAS Suggestion for Contributions*

The Executive Board agreed the Society could not pay AAAS $25 per representative for travel expenses of AAAS Council representatives to attend meetings, because the Society is not able to provide funds for its own Council members to attend ASEE meetings.

20. *Survey of the Teaching of English In Engineering Schools*

Thomas Farrell, Jr., Chairman of the English Division, was granted permission to appear before the Executive Board on Friday night to discuss the proposed study. The Secretary read the action of the General Council taken in November, explaining that almost all of the financing of projects pending at that time has been completed, and that neither the Report On Evaluation of Engineering Education or the Report On the Humanistic-Social Research Project included the study of English, whether oral or written. Professor Farrell stated financial sponsors were available and discussed the financing. The Executive Board VOTED to recommend approval of the project, as a policy matter, to the General Council at its next meeting.

Professor Farrell also stated the English Division would like to take a more active part in the affairs of the Society, and raised the question of bringing technical writers and editors into ASEE.

Respectfully submitted,
W. LEIGHTON COLLINS, *Secretary*

NEW MEMBERS OF THE ASEE

AHLMAN, TORSTEN, Instructor in Engineering Graphics, Purdue University, Lafayette, Indiana. Warren J. Luzadder, J. B. Jones.

ALVERSON, ROY CARL, Research Assistant in Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, Samuel Lerner.

ANDERSON, CARL ANDREW, Graduate Assistant in Aeronautical Engineering, Institute of Technology, USAF Wright-Patterson AFB, Ohio. Paul C. Dow, Jr., Gunther R. Graetzer.

ANDERSON, GORDON FRANCIS, Research Associate in Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, Samuel Lerner.

ANDERSON, JOHN ROBERT, Assistant Professor of Engineering Drawing, University of Miami, Coral Gables, Florida. W. Hubbell, J. H. Clouse.

ANGULO, CARLOS MANUEL, Associate Professor of Engineering, Brown University, Providence, Rhode Island. D. C. Drucker, Z. Bliss.

BEDELL, ROBERT K., Instructor in Mechanical Engineering, The Cooper Union School of Engineering, New York, New York. M. Alpern, William Vopat.

CAMPBELL, ROBERT JOHN JR., Assistant Professor in Ceramic Engineering, University of Washington, Seattle, Washington. J. I. Mueller, D. C. McNeese.

CLIFFORD, WAYNE E., Engineering Personnel Manager, Airesearch Manufacturing Co., Los Angeles, California. D. E. Whelan, Jr., Robert Moses.

CREVELING, JOHN H., JR., Coordinator of Cooperative Program Engineer, University of California, Berkeley, California. E. P. De Garmo, L. E. Davis.

D'ERRICO, THOMAS R., Associate Professor in Civil Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. R. A. McFarland, B. T. Bogard.

DUFFY, JACQUES W., Assistant Professor in Engineering, Brown University, Providence, Rhode Island. Samuel Lerner, Z. Bliss.

EMBRY, BERTIS LLOYD, Associate Professor in Electrical Engineering, Utah State Agricultural College, Logan, Utah. Larry S. Cole, J. E. Christiansen.

FERRAND, EDWARD FRANCIS, Assistant Professor in Chemical Engineering, Cooper Union, New York, New York. Arthur H. Radasch, J. Merriam Peterson.

GORMAN, PAUL J., Engineering Drawing Instructor, Franklin Technical Institute, Boston, Massachusetts. R. R. Borden, L. R. Dantona.

HAMILTON, JAMES FRANCIS, Assistant Professor in Mechanical Engineering, West Virginia University, Morgantown, West Viriginia. R. D. Slonneger, J. M. Strait.

HAYT, WILLIAM HART, JR., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Indiana. Stuart Johnson, Philip Weinberg.

HAYTHORNTHWAITE, ROBERT MORPHET, Assistant Professor in Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, D. C. Drucker.

HERNLEY, KENNETH PAUL, Instructor in General Engineering, University of Washington, Seattle, Washington. D. C. McNeese, Thomas W. Macartney.

INGRAM, GERALD E., Instructor in Civil Engineering, Purdue University, Lafayette, Indiana. J. H. Porsch, J. N. Arnold.

KENT, JOSEPH C., Assistant Professor in Civil Engineering, University of Washington, Seattle, Washington. J. A. Higbee, B. T. McMinn.

LARSEN, LAURIE WORDEN, Training Coordinator, Personnel, Airesearch Mfg. Co., Los Angeles, California. D. E. Whelan, Jr., Robert Moses.

LIEBESKIND, HERBERT, Assistant Professor in Chemical Engineering, The Cooper Union, New York, New York. Milton Alpern, Richard G. Coulter.

LOCKHART, FRANK JONES, Professor of Chemical Engineering, University of Southern California, Los Angeles, California. C. M. Beeson, R. E. Vivian.

MAEDER, PAUL FRITZ, Professor of Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, Samuel Lerner.

MAYER, HERBERT CARLETON, JR., Supervisor of Education, General Electric Co., Kennewick, Washington. Melbourne Jackson, J. Hugo Johnson.

MOORE, RICHARD K., Associate Professor, Acting Chairman, Electrical Engineering, University of New Mexico, Albuquerque, New Mexico. M. E. Farris, R. C. Dove.

MURPHY, CLINTON ELLIS, Instructor in Engineering, Texas College of Arts and Industries, Kingsville, Texas. C. V. Mooney, F. H. Dotterweich.

MURPHY, KARL M., Assistant Professor, English Department, Georgia Institute of Technology, Atlanta, Georgia. R. L. Sweigert, Alton A. Hobgood.

NAMYET, SAUL, Assistant Professor in Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. John B. Wilbur, Myle J. Holley, Jr.

NASH, CHARLES DUDLEY, JR., Instructor in Mechanical Engineering, The Ohio State University, Columbus, Ohio. George N. Moffat, W. L. Starkey.

PAINTER, JACK TIMBERLAKE, Assistant Professor in Civil Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. R. A. McFarland, R. A. Smith.

PECK, GEORGE VAIL, Professor in Civil Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. W. Irwin Short, R. F. Edgar.

PFEFFER, CHARLES B., Assistant Professor in Engineering Drawing, University of Wichita, Wichita, Kansas. W. A. Simons, Everett L. Cook.

RAUTALA, PEKKA, Associate Professor in Chemical and Metallurgical Engineering, Purdue University, Lafayette, Indiana. T. J. Hughel, R. Schuhmann, Jr.

RESNICK, ROBERT, Assistant Professor in Physics, University of Pittsburgh, Pittsburgh, Pennsylvania. W. Irwin Short, John W. Graham, Jr.

ROPER, KENNETH HALL, Instructor, Aeronautical Engineering, Institute of Technology, USAF, Wright-Patterson AFB, Ohio. V. S. Haneman, Jr., P. C. Dow, Jr.

ROY, FRANCIS C., Assistant Professor in Mechanical Engineering, Louisiana Polytechnic Institute, Rushton, Louisiana. J. C. Ramsaur, J. G. Chumley.

SANTALO, MIGUEL ANGEL, Assistant Professor in Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. W. A. Wilson, A. L. Townsend.

SHAPIRO, ELI, Associate Dean and Professor of Finance, School of Industrial Management, Massachusetts Institute of Technology, Cambridge, Massachusetts. E. H. Schell, E. L. Bowles.

SOGIN, HAROLD H., Assistant Professor of Engineering, Brown University, Providence, Rhode Island. D. C. Drucker, Z. R. Bliss.

SUN, HUN H., Assistant Professor in Electrical Engineering, Drexel Institute of Technology, Philadelphia, Pennsylvania. Martin N. Kaplan, I. Cogan.

SYMONDS, PAUL SOUTHWORTH, Professor of Engineering, Brown University, Providence, Rhode Island. Z. R. Bliss, D. C. Drucker.

ULRICH, EDGAR, Mechanical Engineer, Pennsylvania State University, Ordnance Research Laboratory, State College, Pennsylvania. A. T. Thompson, R. F. Marboe.

VANZANT, HOWARD CLAY, Instructor in Engineering, Texas Western College, El Paso, Texas. Floyd A. Decker, Eugene M. Thomas.

WALTERS, ROBERT E., Instructor in Mathematics, University of Louisville, Louisville, Kentucky. Leo B. Jenkins, Jr., J. R. Snowden.

WANG, HUNG-EN, Research Assistant in Engineering, Brown University, Providence, Rhode Island. Paul Kistler, Z. R. Bliss.

WIESNER, JEROME BERT, Professor of Communications and Director, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts. M. M. Boring, W. L. Collins.

WILBURN, RAYMOND N., Supervisor, Engineering Education, The Glenn L. Martin Company, Baltimore, Maryland. John M. Hollyday, H. R. Bartlett.

WOOD, ALBERT DOUGLAS, Research Assistant in Engineering, Brown University, Providence, Rhode Island. P. Kistler, Z. R. Bliss.

50 new members
481 previously added

531 new members this year

FRANK C. HOCKEMA

A member of the ASEE from 1921, Dr. Frank C. Hockema died February 3, 1956, in Lafayette, Indiana. For more than ten years, he had served in the dual capacity, both as Executive Dean and as Vice President of Purdue University. In addition to these administrative duties, he served as professor of mechanical engineering, secretary of the Purdue University Board of Trustees, and as an industrial consulting engineer. He was also regional director for the Association of Governing Boards of State Universities and Allied Institutions.

JAMES B. MACELWANE

James B. Macelwane, S. J., Dean of the Institute of Technology, Saint Louis University, died February 15, 1956, in St. Louis, Missouri. A member of the ASEE since 1946, Father Macelwane was Chairman of the Missouri-Arkansas Section for 1955–1956. An eminent geophysicist, he developed seismographic processes for locating petroleum and mineral deposits. He was also serving as the Chairman of United States activities in connection with the Geophysical Year.

MINUTES OF THE EXECUTIVE BOARD MEETING

Park Lane Hotel, Denver, Colorado
April 27 and 28, 1956

Editorial note: For JOURNAL presentation the minutes below have been shortened somewhat by omitting details of an informational nature. Questions pertaining to the minutes should be directed to the Secretary.

A meeting of the Executive Board of The American Society for Engineering Education was held in Room 608 of the Park Lane Hotel at Denver, Colorado, on April 27, 1956, 6:30 P.M. Because of the forty-odd items on the agenda, the meeting was adjourned at 11:30 P.M. to 28 April, when another dinner meeting was held, the time and place being the same. The Board also on 28 April attended the sessions of the Rocky Mountain Section of the Society at the University of Denver. Those present at both sessions were: M. M. Boring, President; F. C. Lindvall, L. J. Lassalle, W. T. Alexander, and H. K. Work, Vice Presidents; G. W. Farnham, Treasurer; W. Leighton Collins, Secretary; and E. C. McClintock, Jr., as Editor. Thomas Farrell, Jr., Chairman of the English Division, was present for a short time on April 27.

1. *Report of the Secretary,* W. Leighton Collins

(a) After having been sent the usual three dues notices, there still are 856 individual members and 9 institutional members who have not paid their dues. The total value of the arrearages is almost $11,500. A special letter was sent to the institutional members by the Secretary and to the individual members by the Treasurer. The Executive Board VOTED that the Secretary adhere to the provisions of the Constitution and submit to the General Council at each Annual Meeting a list of members whose dues will be two years in arrears at the end of the current fiscal year, the General Council at its June meeting then taking action to drop from membership at the end of the current fiscal year all who are still two years in arrears at that time. It was suggested that the drop notice be sent by certified mail.

The Executive Board also VOTED to refer to the Constitution and By Laws Committee a possible change in Section 5 of Article XI, second sentence, believing that "dropped from the role of the Society until such arrearages are paid" is unworkable for efficient office practice. A "dead file" of members is not maintained, and members once dropped resent or refuse to pay two or three years back dues when they want to rejoin. It was believed paying arrearages for the one year such members receive the JOURNAL would be more appropriate; for this purpose, perhaps, a file of dropped and resigned members should be maintained.

(b) About 500 new individual members have joined the Society during

the fiscal year. Associate Institutional Members approved since the last meeting of the Executive Board are: American Viscose Corporation; Vickers, Inc.; International Paper Company—Southern Kraft Division; Sperry Gyroscope, Division of Sperry Rand Corporation. The following were submitted for Associate Institutional membership and the Executive Board VOTED to approve them: McDonnell Aircraft Corporation; Charles Bruning Company; Convair—A Division of General Dynamics Corporation. The Executive Board also VOTED to accept Sacramento State College as an Affiliate Institutional member.

(c) The plans for disposing of excess volumes of *Proceedings* to libraries both overseas and in this country has reduced the number stored at Lancaster Press (volumes 1 through 55) from about 1200 to 225. Extra copies of the JOURNAL currently being held for *Proceedings* use have been reduced by 100; this economy is expected to avoid an excess of current volumes.

It was agreed to refer to EJC the U. S. Information Agency's letter of December 22, 1955, complimenting the Society for its cooperation and lamenting the lack of current technical periodicals available for distribution abroad.

(d) 10,000 copies of the Humanistic-Social Report are being printed and, in addition, it will be presented in the April issue of the JOURNAL. The letter ballot of the General Council was overwhelmingly in favor of acceptance of the report. Though the report is longer than originally planned, it was agreed the selling price should remain at 25¢ each, 20¢ each for lots of 50 to 100, and 12¢ each in lots of 100 or more. John Mattill of MIT, Chairman of the Public Relations Committee, prepared a news release for the report. The material was assembled in cooperation with the Carnegie Corporation, the grantor of the funds for the project, and the director of the project.

(e) The papers presented for the Nuclear Institute at Northwestern University in 1954 have been turned over to the Secretary. Since the original budget included an item for publication of a report, the Executive Board authorized the Secretary to investigate the availability of the funds and, if adequate, to develop plans for publishing the papers, charging all costs thereof to the fund.

(f) Reports were made on the following summer programs.

1. *Institute on Mathematics In Engineering.* Dean F. C. Lindvall reported that the remainder of the funds had been transferred to the University of Michigan, and that Professor George Hay was now completing the details of the program.

2. *Institute for Engineering Teachers at Argonne National Laboratory.* The Secretary reported that the letter ballot of the General Council unanimously approved the Argonne Institute. About 160 applications to attend had been received; only 60 could be accepted. As a result of this interest, the holding of a similar course at Brookhaven National Laboratory for 30 applicants is being investigated. The Executive Board VOTED to approve the institute at Brookhaven because it actually is merely an extension of the Argonne program.

3. *Summer Schools.* The Secretary reported that the programs for the three summer schools to be held in conjunction with the Annual Meeting

at Ames (Humanistic-Social, Construction Education, and Engineering Drawing) are essentially complete, and that a brochure publicizing them had been prepared and mailed.

4. *YET Program.* President Boring reported that the proposed program did not develop because only one company made a firm commitment. The proposal had been to employ YETS for the summer and give them a month's leave of absence, with pay and expenses, to attend a conference on teaching techniques and methods.

5. *General Electric Summer School.* President Boring reported that because ASEE's YET program for the summer failed to materialize, the General Electric Company desired to repeat its summer school for college teachers. The General Electric Company will select 30 YETS and bring them together to learn something of how industry operates. G. E. pays all expenses and it has been customary to seek ASEE approval. The Executive Board VOTED to approve the program.

(g) Because some institutional members are receiving two copies of the JOURNAL OF ENGINEERING EDUCATION and others one, the Executive Board VOTED that all Institutional members should receive two copies of the JOURNAL if they desired them.

(h) At the suggestion of Lancaster Press, steps were successfully taken to obtain a lower mailing rate for the JOURNAL. A saving of about $270 per year should result.

(i) In response to a request received, the Executive Board VOTED not to establish a group subscription rate for the JOURNAL.

(j) Board members attended ten Section meetings and two Mid-Winter Division meetings during the year. It was agreed that next year an attempt should be made to have a national officer visit the Sections not visited this year, the Secretary's office serving as a clearing house for requests in order to avoid duplication of travel. Expenses for attendance of officers to some of these meetings can be paid by the Society.

(k) M. M. Boring was invited, as President of the Society, to represent ASEE on the National Committee for Development of Scientists and Engineers. The Executive Board authorized the Secretary to write President Eisenhower stating that the Executive Board believes Mr. Boring can best represent the Society on this committee, such representation not being contingent upon his being President of the Society.

The Executive Board VOTED that officers appointed to *ad hoc* committees should continue on the committees until the work is completed, regardless of whether or not they are still in office.

(l) The Executive Board VOTED to recommend to the Constitution and By Laws Committee that all officers of the Society be kept on the General Council for three years after stated terms of office expire, and that a copy of this recommendation be sent to the Society Functions Committee.

2. *Report of ECRC*, H. K. Work

(a) The Executive Board VOTED to approve the name "Vincent Bendix Medal" for the gold medal to be given annually for outstanding research, and to require a "termination clause," such as one year's notice by either party, in the agreement to be made with the Bendix Corporation.

No conclusion was reached regard-

ing the name for the $1,000 cash award to a young research worker. It was the belief of the Executive Board that the name should have some significance in research or teaching, and Dr. Work was instructed to discuss this with the ECRC Executive Board and the prospective sponsors.

(b) The plans for the ASEE–NSF Study of Research Needs have been agreed to by both NSF and ECRC. The request for funds has been submitted to NSF, but the grant has not yet been made. The study will be started, under the direction of Dean E. C. Walker, as soon as the funds are received.

(c) The two new ECRC members approved are Worcester Polytechnic Institute and Marquette University.

(d) 817 copies of the Review of Current Research have been sold and about 400 more have been sent to Institutional Members of ASEE. E. C. McClintock is to investigate the requirements for getting a Second Class mailing rate.

3. *Report of ECAC,* W. T. Alexander

(a) The Industrial Fellowship Program is still headed by ECAC Secretary Ralph Morgen. The Executive Board agreed the procedure of having a Council develop an idea until a workable plan and procedure is developed was sound, but that the Society should not have several small offices established to conduct the work for the various Councils; instead, the work of the Society should be concentrated in a single central organization under the direction of the Secretary. The Executive Board VOTED that as of 1 July, 1956, the Industrial Fellowship activity be transferred to the Secretary's office, that this activity then become a Society function, and that a new Society committee be appointed from ECAC and ECRC, the purpose of the committee being to carry out the "random selection" of institutions and to advise the Secretary on other matters pertinent to the fellowship program.

(b) The possibility of having the Society administer the AEC fellowship program was discussed. After much deliberation it was agreed the handling of such a complex program was beyond the scope of activity of the Society. Reasons for the decision centered on the undesirability of having to select recipients and schools, the tremendous variations in capabilities to do atomic research, the problems of administering security provisions, and the requirements for increased staff and space.

(c) The *ad hoc* committee on Accrediting Practices in New York State is working to get the New York authorities for the registration and licensing of engineers to discontinue their own accrediting and accept ECPD accreditation. By law they can accept, at their discretion, accreditation by other organizations.

4. *Report of Vice President in Charge of Sections,* F. C. Lindvall

Details of procedure at the Annual Meeting were discussed. The Secretary noted that Sections needed to understand that members of the General Council continued to serve until ten days after the Annual Meeting, regardless of the time of year when elections had been held.

5. *Report of Vice President in Charge of Divisions,* L. J. Lassalle

Information regarding Divisional publications and methods of financing them has been coming in, and a full

report will be made at the Annual Meeting.

6. *Report of the Treasurer,* G. W. Farnham

(a) The third quarter financial statement was discussed. Receipts and expenditures were in general accord with the budget. The cost of the JOURNAL for the year will be about the same as for last year and within the budget; monthly income for advertising has risen to approximately the level of last year.

(b) The financial status of the eight special projects for which funds have been granted the Society was reviewed. All projects were in satisfactory condition.

(c) As of April 1, 1956 there was a total of $47,679.38 in savings accounts and a balance of $61,831.65, including funds for special projects, in the checking account. It was agreed an additional $10,000 should be placed in a Boston savings bank, W. T. Alexander to provide the Secretary with the necessary information.

7. *Report of the Editor,* E. C. McClintock

(a) The new format, started with the January issue of the JOURNAL, apparently has been well received.

(b) Up to the present time no information has been received which indicates that a saving could be made by printing the Yearbook using an offset process of a quality equivalent to the present letterpress method.

(c) Some secondary school students and advisors have expressed the opinion that the JOURNAL may be good guidance material. This raises the question of whether copies should be placed in libraries of secondary schools.

(d) Cooperation was given John Mattill, Chairman of the Public Relations Committee, in the preparation of the news release for the Humanistic-Social Report.

(e) The Executive Board agreed that the statistics on enrollments and degrees granted should be kept together in one article, the Secretary being instructed to so inform H. H. Armsby.

(f) The suggestion was made that more pictures and biographical sketches were desired, particularly for Society officers, and for chairmen of special projects.

8. *Handling of Funds for Special Studies*

(a) The Secretary reported difficulties arising from some of the present methods of handling funds for special projects. In some cases where funds went directly from grantor to the administering group there has seemed to be a lack of responsibility for "winding up" matters, and the Society seems to have no real responsibility or control. The Executive Board VOTED that in the future when funds are solicited by or in the name of the Society, the money is to remain under the control of the Secretary's office and be disbursed by him as required.

(b) There have been a few cases when travel expenses for committee members from industry were paid by the Society. The Executive Board VOTED not to pay travel expenses for industrial members of committees attending meetings for special studies, and that such a statement be incorporated in agreements with the grantors of funds.

9. *Fund Solicitation*

(a, b.) The financial needs of Sections and Divisions and ways of obtaining the needed funds were

discussed, but no action was taken. F. C. Lindvall submitted information relative to the problems of the Pacific Southwest Section.

(c) The need for increased funds to pay travel expenses for Society representatives on committees of other societies, for General Council members, etc., was discussed. In order to initiate some action, the Executive Board VOTED to recommend to the General Council that dues of Associate Institutional members be increased from $50 to $150 per year and that an *ad hoc* committee of the General Council be appointed to draft an appropriate letter which would notify the Associate Institutional members of the change.

10. *Engineers Joint Council Activities*

(a) The Executive Board VOTED to recommend to the General Council approval of the American Society for Agricultural Engineers as an associate member of EJC.

(b) President Boring reported that EJC's Surveys Committee is functioning under their Employment Conditions Committee. It had been proposed that a joint program could be established for these committees of EJC and our Evaluation Follow-Up Committee. President Boring is to pursue the matter to a satisfactory conclusion.

(c) Dean M. P. O'Brien has been recommended to EJC as the Society's representative on the Joint Committee for the Study of the Engineering Profession.

(d) A memorandum from EJC dated 29 March 1956 stated that the EJC Board of Directors had voted to recommend the deletion of Par. 2, Article VIII of their constitution, which pertains to the use of dues income during the "fiscal year" as the basis for determining "proportionate financial support," and asked for action on the recommendation by the Constituent Societies. The Executive Board agreed that it could see no disadvantages to the deleted plan, and, because this plan enabled an audited figure to be used, instructed the Secretary to write EJC saying the Executive Board recommended that Par. 2 of Article VIII remain unchanged.

11. *Engineers' Council for Professional Development Activities*

(a) At the 1955 Annual Meeting of ECPD it was voted that the Council recommend to each constituent engineering society that they request each new member who joins a particular society to signify his acceptance of the Canons of Ethics, or of the code of ethics of the Society, as a condition of membership. It was unaminously agreed by the Executive Board that ASEE had no need for and would not gain from such a requirement and, consequently, should not require new members to signify acceptance of a code as stated in the ECPD action.

12. *Group Insurance for ASEE Members*

The Executive Board VOTED not to participate in the plan suggested by Smith and Sternau because, if all other engineering societies participate, most ASEE members will already have had an opportunity to participate.

13. *U. S. Mission to Russia*

The Executive Board VOTED that the Society should not ask the State Department for permission to have a five or six man team of engineering educators visit Russia and study the Soviet system of engineering education. It was believed that initiation

of such a project would involve responsibilities the Society should not assume.

14. *Sponsorship of Engineering Society for Junior College Students*

The Executive Board agreed that such inquiries should be referred to the appropriate State Society of Professional Engineers. A study of the records indicates that ASEE had a Junior College Division in 1949; it was unsuccessful because of a lack of interest.

15. *Technical Meetings with High School Teachers*

EJC has requested its constituent societies to consider permitting high school teachers to attend society meetings without having to pay registration fees, or with reduced fees. The Executive Board agreed to refer the matter to the General Council for action, believing it advantageous to do something on the Section level, but doubting that there would be an interest in the Annual Meeting.

16. *Council for Basic Education*

The Society was invited to become an associated organization of the Council, no financial obligation being entailed. As a member of the founding group, President M. M. Boring reported that the Council was financially supported by the William Volker Fund, with the object of getting more as well as better mathematics and science into high schools. The Executive Board agreed to take no action at this time, but President Boring is to keep the Executive Board informed of developments.

17. *Future Meetings*

(a) The Executive Board agreed that the week of June 16 was preferable to the week of June 9 for the Annual Meeting at Berkeley in 1958.

(b) The Secretary called attention to the fact that if the geographical rotational scheme for holding meetings was adhered to, the 1960 meeting should be held in the South or Southeast.

(c) The Fall meeting of the Executive Board follows the ECPD meeting, as previously agreed, and is to be on Friday, October 26, 1956. A 6:00 P.M. dinner meeting will be held at the Engineering Society of Detroit, Detroit, Michigan.

(d) The Fall meeting of the General Council also follows the ECPD meeting, as previously agreed, and is to be on Saturday, October 27, 1956, at 7:30 A.M. The breakfast meeting is scheduled for the Ivy Room at the Statler Hotel, Detroit, Michigan.

(e) The Secretary reported that, regrettably, the American Society of Physics Teachers will not meet jointly with ASEE at Cornell in 1957.

18. *Deans' Conference On Atomic Energy*

The letter ballot of the General Council overwhelmingly approved the program. ASEE, the Atomic Energy Commission, the National Science Foundation, and the Oak Ridge Institute for Nuclear Studies are joint sponsors. NSF is providing the funds for travel and *per diem* expenses. The dates are September 5–8 at Gatlinburg, Tennessee. All deans of engineering of ECPD approved schools, the presidents of those institutions, the members of our Atomic Energy Education Committee, and the President and Secretary of ASEE are to be invited. Plans are being developed by our Atomic Energy Education Committee.

(For items 19 and 20, please see page 803.)

ECPD Additional Criteria for Accreditation

INTRODUCTION AND BACKGROUND

HAROLD L. HAZEN

Chairman, Education and Accreditation Committee, ECPD
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Since the Engineers' Council for Professional Development (ECPD) began accreditation of undergraduate engineering curricula in the early 1930's, there has been continuing discussion of the question "What is an engineering curriculum?" The long-established and recognized fields, beginning with Civil Engineering, are clearly engineering, but how about Geological Engineering or Engineering Physics? Are curricula in these fields appropriately regarded as engineering curricula or not? Such curricula were often informally called "fringe" curricula in ECPD, a designation that did not question the quality but only the field of the curriculum for purposes of accreditation.

In an attempt to answer this question after discussions extending over a period of years, Council of ECPD, on recommendation of the Education Committee, approved as a principle of operation a statement concerning so-called "fringe" curricula which appeared in the twenty-second *Annual Report* (September 30, 1954) of ECPD and was published in the January, 1955, issue of the JOURNAL of ENGINEERING EDUCATION. In this statement there were recognized two categories of engineering curricula, viz., *major* engineering curricula and *cognate* engineering curricula. A set of semi-quantitative criteria was given by which either a major or cognate curriculum could be tested. If a curriculum satisfied these tests or criteria, it was considered by ECPD to qualify as an engineering curriculum. This was a step in the direction of placing relatively more emphasis on the nature and content of the curriculum than on its name in determining whether or not it qualified as an engineering curriculum for purposes of accreditation.

Although little discussion occurred concerning the criteria, much and indeed rather violent opposition developed among some whose curricula had been designated as "cognate." These maintained that any curriculum that was not major was obviously minor, and therefore inferior in status. "Cognate" status was unacceptable, however respectable Mr. Webster might consider it.

But discussion over the so-called "cognate curriculum" statement paved the way for the next step, which was to disregard the name and look entirely at the nature and content of the program

to determine whether or not it would qualify as an engineering curriculum. Working in this direction, the Education Committee of ECPD prepared a statement of "Additional Criteria for Accreditation of Engineering Curricula" to supersede the unacceptable "cognate" statement. In principle this "additional criteria" statement says that the name of an engineering curriculum is of minor concern to ECPD and is primarily the business of the institution offering the curriculum. What ECPD *is* concerned with is the character and content of this curriculum. This "statement of additional criteria" was accepted as a working principle by the Council of ECPD in Toronto on October 16, 1955, and appears as a part of the report of the Committee on Education and Accreditation in the twenty-third *Annual Report* of ECPD, dated September 30, 1955.

It should be emphasized here, as it is in an indication itself, given below, that the additional criteria are not a set of rigid, inflexible rules, but rather an indication of what are regarded as sound principles which will serve as a guide in ECPD appraisals for a least a year or two. In regarding this statement as a guide rather than a set of rigid rules, it is meant, for example, that a curriculum might technically satisfy all of the additional criteria and yet be taught under such circumstances that ECPD could not approve it for accreditation. On the other hand, a curriculum might fall somewhat short of meeting these criteria in certain respects and yet be taught by such a faculty and under such circumstances that it was clearly a strong engineering curriculum and therefore acceptable for ECPD accreditation. Therefore these additional criteria are merely a part, albeit an important part, of the criteria used by ECPD in its evaluation.

In the "additional criteria" statement and in exercising broad judgment regarding minimum acceptable standards, ECPD is taking fully into consideration the report of the ASEE Committee on Evaluation of Engineering Education. Eleven members served on both the Education Committee of ECPD and the Evaluation Committee of ASEE, so the cooperation has been close. It should be emphasized, however, that the objectives of the reports presented by the Evaluation Committee and by ECPD's Education Committee differ in one important respect. The Evaluation Committee's function was to formulate a pattern and ideals for the improvement of engineering education applicable to strong as well as to less strong schools. The ECPD function, on the other hand, is basically to set and to act in accordance with *minimum* standards for accreditability. Thus, while there is a close relation between the two activities, the ends or objectives are different; consequently the *ideals* of the Evaluation Committee should differ from a statement of *minimum standards* for ECPD accreditation.

ADDITIONAL CRITERIA FOR ACCREDITATION OF ENGINEERING CURRICULA

As approved in principle by the Engineers' Council for Professional Development at its Twenty-Third Annual Meeting, Toronto, Canada, October 13–14, 1955.

1. In order to assist identification and recognition by ECPD accreditation of those curricula that constitute adequate undergraduate educational preparation for engineering, the following criteria supplemental to those regularly published in the Annual Report of Engineers' Council for Professional Development under "Objectives and Procedures" for Accrediting Engineering Curricula will serve as a guide in ECPD accrediting activity. These criteria have as their object the assurance of an adequate foundation in science, humanities, engineering science, and introduction to engineering method, while providing sufficient flexibility in science requirements to accommodate curricula requiring special backgrounds, such as life science or earth science. They also provide substantial flexibility for expression of the institution's own individuality and ideals. Finally, they are regarded as a statement of principles to be applied with judgment in each case rather than with arbitrary rigidity.

2. The supplemental criteria are:

a. All curricula shall contain at least the equivalent of one academic year of mathematics and basic science about equally divided.

b. All curricula shall contain at least the equivalent of approximately one year, except as provided in 2-c, of engineering sciences, including most and preferably all of the following:

1. Mechanics of solids (statics, dynamics, strength of materials)
2. Fluid mechanics
3. Thermodynamics
4. Transfer and rate mechanisms (heat, mass, momentum)
5. Electrical theory (fields, circuits, electronics)
6. Nature and properties of materials (relating particle and aggregate structure to properties)

Only after careful consideration and determination that the fundamental concepts are substantially covered in other studies at an equivalent mathematical level, should one of these engineering sciences be omitted from a curriculum.

c. Because some engineering curricula are built in part on sciences not included in the preceding paragraphs, such curricula may contain for additional flexibility other basic or engineering sciences appropriate to their fields, to an extent equivalent to one-third of an academic year, in lieu of an equal portion of time otherwise devoted to the engineering sciences listed in 2-b.

d. Approximately the equivalent of one-half of an academic year shall be devoted to engineering analysis, design, and engineering systems.

e. The curriculum shall be designed as an integrated sequential study in the scientific and engineering area.

The mathematics and the basic science are to be used proficiently in the work in engineering analysis, in the study of engineering systems, and in the preparation for creative design.

f. The equivalent of one-half year to one full year of the curriculum shall represent the minimum content in the area of humanistic and social studies. Of this content, at least one-half year should be selected from the fields of history, economics, government, literature, sociology, philosophy, psychology, or fine arts, and should not include such courses as accounting, industrial management, finance, personnel administration, or ROTC.

g. The two pressures on four-year engineering curricula for inclusion of more newly developing engineering science and for an increase in the social-humanistic content make it necessary that neither the technical-scientific nor the social-humanistic content of such curricula be reduced below the minimum requirements of paragraph 2 above to make room for advanced ROTC programs. This procedure views realistically the fact that the engineering student taking advanced military science is in effect pursuing two curricula simultaneously with separate and different requirements and objectives.

3. In any case in which the Education and Accreditation Committee is persuaded that well-considered experimentation in engineering curricula is under way, it shall give sympathetic consideration to departures from the criteria of Sec. 2 and shall make appropriate recommendations to ECPD.

4. The committee recognizes that these recommendations constitute a departure from past practice in that an approach is made to quantitative criteria for curriculum content and distribution of time.

5. The committee continues to favor broad basic undergraduate programs in engineering which will prepare a student to take advantage of as many different opportunities as possible, and prefers to minimize the number of specially designated curricula to be considered for accreditation. The committee is prepared to examine for approval any curriculum that appears likely to satisfy its criteria for an undergraduate engineering curriculum.

Curricula of a vocational or technical institute pattern cannot qualify, nor can curricula of so specialized a pattern as to provide an inadequate base for engineering of professional level.

MEET YOU AT AMES

Report of the Prototype

CHICAGO INDUSTRY–EDUCATION CONFERENCE

on the ASEE Evaluation Report

The following condensation represents the major thinking at an exploratory conference held March 6, 1956, in the Western Society of Engineers Headquarters, 84 East Randolph Street, Chicago. The purpose of the meeting was to invite an expression of industrial views about the pattern of engineering education set forth in the ASEE *Evaluation Report*. Executives from industry in and around Chicago, members from the Committee on Evaluation of Engineering Education, and administrative and faculty representatives of the midwestern Engineering colleges attended the conference.

Two discussion sessions and a luncheon made up the meeting. Both sessions were based on the text of the *Evaluation Report*, which had been distributed previously. Written expressions of opinion were also invited and then incorporated, with numerous suggestions received. Significant excerpts are presented below, both for their intrinsic interest and as a possible aid in arranging similar discussions throughout the country. (Outlines of procedures have also been prepared, and are available from the Follow-Up Committee.)

The prototype group assembled on joint invitation by Mr. H. P. Sedwick, President of the Public Service Company, Chicago, who served as principal discussion leader, and Dean W. L. Everitt, College of Engineering, University of Illinois, chairman of the ASEE Follow-Up Committee on the Evaluation Report. Attendance, especially from industry, exceeded expectations, and discussion interest was high.

The principal views expressed emphasized that the *Report* recommendations definitely looked in the right direction, toward a well-rounded engineering graduate with sound, basic learning readily transferable to any field of professional activity. Though there is always need and possibility of improvement in engineering education, the key problem facing technical colleges today is that of obtaining and holding adequate numbers of superior faculty members. Better utilization of faculty talents without loss of teachers can be achieved through part-time efforts both in research and in stimulation of industrial thought. These gains can be achieved with the wise assistance of industry.

The Graduate

Some of the major needs of engineering graduates appear to be for improved skill in communication and logical thinking, the development of creative imagination in design and problem-solving, administrative capacity and ability to deal effectively with other people, plus high ethical and professional standards and sense of responsibility. It was agreed that these should continue to be developed,

under industry tutelage, for many years after graduation.

Colleges are primarily responsible for instruction in basic science, effective communication, and a well-rounded background in humanistic studies. In contrast, engineering arts and "know-how" required for industrial purposes can best be taught by the companies themselves, whether large or small. The professional engineering societies can be a great help to students entering engineering, especially in obtaining proper high-school preparation. There is a need for improved communication between industry and educational institutions, and this is essential for mutual understanding and aid. With a wide circulation of the Evaluation Report and subsequent meetings of similar industry-education groups, possibly with secondary school officials in attendance, it is believed that by joint action many problems can be solved.

Program in Detail

The session was opened with a brief explanation of the *Evaluation Report* objectives, emphasizing (a) the high qualifications needed in engineering teachers, (b) the need for a liberal point of view in all courses, (c) mutual strengthening of relations between teaching and research, and (d) the distinction between *science or analysis* (seeking answers to questions of what happens under given circumstances) and *engineering or synthesis* (the use of materials and natural laws or forces to obtain desired results). The need for re-orientation of engineering curricula toward both basic and engineering sciences, including humanities, was also developed.

The critical problem for colleges and universities is that of obtaining expanded high-quality faculties and facilities for instruction. A youthful point of view and adaptability to new conditions is considered essential for teaching success, after subject-matter competence.

Industry can help most in supplementing salaries and opportunities of engineering faculties by encouraging teachers to act as consultants, as research investigators within their own college, and as idea-sources, but not by recruiting them as full-time industrial employees. Thus staff members can continue their teaching while they contribute to scientific knowledge and industrial success. Industry thereby can stimulate effectively the production of engineering graduates in greater numbers for the future.

Summer employment programs, if realistically priced at something like 50% of winter-session salaries, can also be of significant assistance to engineering faculties. Industry can gain the advantage of both university and industrial facilities by employing teachers' productive-thought time at home, in their own colleges. It was also suggested that engineering deans recommend younger men, as well as more mature staff members, for consultant assignments to gain industrial training and practice. Such experience will reflect beneficially on teaching and will encourage top-quality performance.

The industrial representatives emphasized that engineering faculties are now doing a good job and that industry suggestions are aimed only at the improvement which is always possible, even under the best of circumstances.

A Chicago industry representative felt the *Report* was particularly strong in urging study of the basic sciences

first, followed by the engineering sciences. The practical side of engineering, he felt, can best be obtained in business after graduation; colleges should establish a sound basis for this later development. Special educational topics are less important than the personal guidance and stimulus of brilliant instructors.

Cooperation and Thought

Another industry representative from the Chicago area pointed out that students need to realize the difference between cooperative or conference work in contrast to the dreariness of single labor and the loneliness of individual thought. However, an engineer needs patience and an objective view of others, as well as of himself, for successful teamwork.

An employment director noted that while top engineers might logically be expected to evolve into managers or executives, he had encountered a surprisingly negative student reaction to the importance of English, a basic management tool. Most students, he felt, were likewise either completely inadequate or seriously deficient in *science* preparation (75% for entering students, according to a survey by an Eastern university).

An executive of a heavy equipment firm expressed the belief that there is an important difference between English, and humanities or other non-professional courses. Practice in effective expression, he felt, is an essential part of professional training. He was inclined to resist weakening the curriculum with too much humanities, but felt that English should be included as a major aspect of professional studies in engineering.

At Chairman Sedwick's invitation to comments on curricular revision or improvement of teaching, an educational administrator stated that, in line with the recommendations of the *Report*, his institution had disposed of its electrical machinery laboratory and equipment. In removing limitations on imaginative thinking, he considered this to be at least experimentation, if not revolution.

An executive of a leading electrical manufacturing company reported that the constantly increasing size and complexity of industry calls for much more *general* education and capabilities than in the past. The engineering graduate today needs to be well-rounded, with diverse competencies, not narrow and highly specialized. Also, he felt that an undergraduate curriculum in any branch of engineering, plus graduate study in business administration (with a considerable segment of humanities courses in each), would be of great assistance.

The executive of the heavy equipment firm mentioned above suggested a research study of non-engineering skills among engineering employees in industry. Topics to be considered could include the background of these skills, when and where they were acquired, and the means or methods most successful in the development of knowledge, sympathy, and insight.

As the meeting progressed, the spirit seemed increasingly concerned with how to help engineering education, especially engineering faculties, rather than with possible defects of the *Report*. A strong inclination was expressed to accept the *Report*, to conclude that its recommendations were valid, and to insist that the major problem was implementing them and pushing them further. This should be done, it was thought, through providing funds both to engineering and

liberal arts institutions in the hope that they would be able to carry out their functions even more effectively than now. The consensus was one of industrial encouragement to engineering education in carrying out its present work.

Discussion developed next on the dangers of using industrial funds for scholarships only. It was suggested that specific contributions be made to faculty salaries and to the improvement of teaching facilities rather than for general building and grounds purposes. Industry can help faculty members, for example, with grants toward attending summer schools. The dean of a midwestern technological college pointed out that faculties are anxious to study and improve themselves, given the requisite funds and opportunities.

A member of the Evaluation Committee from a Southern university made an extended point that the problems of engineering education were accentuated by the threats of Russian efforts and progress, both in quantity of engineering students (two to one against the United States) and in quality as well. To illustrate, he cited the 1939 situation in electronics, which now has a parallel in the fields of physics and nuclear chemistry. He expressed the belief that dynamic and bold improvements in engineering education are required if we are to be successful in competing with the highly organized Russian system.

He also emphasized that *creative* attitudes are needed in both faculties and engineering graduates, and that impetus must be given to the continued *general education* of the individual. Fixed curricula can serve to "deep-freeze" new ideas; curricular *revision* can stimulate them. Today we need emphasis on the *basic ideas.*

Broad training is important also because graduates so often *change fields* completely in practice. Subjects such as accounting, management, and ROTC are neither science or humanities, and should be considered separately, outside the curriculum, in terms of the quality of their contribution.

In reply to questions, the industrial representatives felt that a streamlining of courses in traditional drawing, in shops and laboratories, and in design would not weaken engineering education. Industry seemed to have faith in the educators' ability to deal with problems of curricular balance as an educational responsibility primarily. There were no indications that industry would be dissatisfied with engineering graduates who possessed broader and more scientific backgrounds.

A practicing civil engineer considered the *Report* a good piece of self-criticism for engineering education and a fine "handbook of desirable practice," with a useful balance of science, engineering science, and humanities. More emphasis and importance, he believed, should be placed on the responsibility of graduates to the *engineering profession,* as members of engineering societies and organizations. He felt that four years were enough for undergraduate training, but that more on-the-job-training and practice would be helpful. Industry often fails to utilize engineers properly and to continue professional education at higher levels. A coworker added that their feelings as civil engineers were not disturbed by the implications of the *Report* for civil engineering.

A Committee representative from Purdue University offered the suggestion that if the important function of teachers in colleges was that of stimulating students, instructors should also be important to industry for their creative ability.

Another civil engineer from the steel industry spoke of the graduates he encountered who lacked a practical command of English. He agreed on the desirability of extended basic training, and illustrated with the experience of a leading electrical instrument manufacturing company, which found *physics* graduates to be more useful than electrical engineers.

A consulting civil engineer contrasted the basic European approach to engineering education in his native Norway with the relatively "handbook" methods prevalent in the United States. He preferred more emphasis on "thinking out" problems rather than on finding formulas into which data could be fitted. (Throughout the conference, the recurrent theme was the need of engineering graduates for skill in logical and imaginative thought processes.) This engineer expressed appreciation of his three years experience as a teacher, and recommended a tour of teaching duty for all superior engineering graduates.

An industrial administrator noted a new attitude of industry toward the development of executive talent. The training of executives is now industry's responsibility. A graduate of three years experience is no longer expected to be capable of vice-presidential responsibilities. Employing companies can and should enhance administrative skills if education will lay a sound and broad foundation for either technical or administrative advancement. Industry, whether small or large, can well bear the burden of practical training in engineering arts —even by organizing summer programs with university staff members as instructors.

Conclusions

It was agreed that

(1) The aim of the *Report* was to plot goals and directions for engineering education over the next 25 or 30 years; this had been done effectively.

(2) The *Report* should be more widely distributed and read, with the aim of obtaining all possible application for its existing recommendations, and of adding comments or suggestions from both industry and education sources.

(3) Improved communciation between industry and education is most important for the further development of engineering education. It was suggested that additional regional meetings of this type, combining representation from the Committee, from industry, and from engineering education, be held to develop better understanding and mutual assistance. The industry members felt particularly that they had gained from the conference a much more vivid sense of educational problems, and now saw much more clearly than before the many opportunities to employ engineering faculty members part-time, and how to utilize the skills and resources of engineering colleges.

(4) Finally, it was believed that joint action by industry, professional engineering societies, and engineering educators should go a long way to solve the problems of engineering education and to advance the interests of the profession and the nation.

The Journal of ENGINEERING EDUCATION

June, 1956 *Table of Contents* Vol 46, No 10

Articles

Do You Know 824

Mechanical Engineers and Nuclear Design — R. J. Fritz 827

Educational Requirements of Technical Editors — P. J. Kalsem 832

Why Do Engineers Dislike Technical Writing? — H. M. Friend 836

Microwave Engineering: How a New Course Is Adopted — Charles Süsskind 838

On Teaching Physical Mechanics — R. J. Seeger 842

Future Scientists of America Foundation — H. H. Armsby 855

Guidance Bibliography for Mathematics 858

Departments

New Members of ASEE 860

Teaching Positions Available 865

Report

EJC: Professional Standards and Employment Conditions 866

Notes

Journal Microfilm Editions 826

EJC Proceedings Available 835

CE-AGC Cooperative Committee 837

Discussion—Nuclear Research Projects 857

A. H. Cooper Ass't Director 857

Gordon Research Conferences 859

Risk Analysis—Discussion 859

Melvin L. Enger 864

Indexes—Volume 46, Nos. 1–10 (Sept., 1955–June, 1956)

Subject-Title 877

Author 880

DO YOU KNOW . . . .

► . . . . That two changes in the method of handling funds granted the Society for special studies were adopted by the Executive Board at its April meeting? One vote was, "When money is solicited by the Society in the name of the Society, the money is to remain under the control of the Secretary's Office and be disbursed as required." Such action should eliminate situations in which there seems to be uncertainty about authority and responsibilities.

The other vote was, "Not to pay travel expenses for industrial members of committees attending meetings and that such a statement be incorporated in agreements with the grantors of funds." This practice is not entirely new, but was necessary to avoid the recurrence of some embarrassing situations. It also may be well to state the Society pays no expenses for anyone attending the Annual Meeting, not even for the President.

► . . . . That officers appointed to ad hoc committees will now continue to serve until the work of the committee is completed, regardless of whether or not they are still in office? This policy was established at the April meeting of the Executive Board. A good horse should not be changed in mid-stream just because he goes out of office. One exception to this policy is the ECRC Chairman's appointment to the National Research Council; though he is appointed for a three-year term, he is expected to resign at the end of the second year in order that the new Chairman of ECRC can represent the Society for two years.

► . . . . That the Industrial Fellowship activity becomes a function of the Secretary's office as of 1 July 1956? This action of the Executive Board was taken after much discussion of how the Society should function. Based on the general principle that the Society should not establish several small secretarial staffs to conduct its work, the Executive Board voted, "That as of 1 July 1956 the Industrial Fellowship activity be transferred to the Secretary's office, that the activity then become a Society function, and that a new Society committee be appointed from ECAC and ECRC, the purpose of the committee being to carry out the 'random selection' of institutions and to advise the Secretary on other matters pertinent to the fellowship program."

► . . . . That an inquiry has been received about the interest in a group insurance plan for members of ASEE? Most of you probably know that ASCE has such a plan for its members. Smith and Sternau now are approaching the other constituent societies of Engineers Joint Council. The Executive Board voted not to participate in the plan because if the other societies adopt it most of our members will have an opportunity to participate.

► . . . . That the Dean's Conference on Atomic Energy is to be held at Gatlinburg, Tennessee, on September 5–8? Deans of engineering schools having ECPD accreditation, the presidents of those institutions, the members of our Atomic Energy Education Committee, and the President and Secretary of ASEE are to

be invited. The program is being developed by our AEEC in conjunction with AEC, NSF, ORINS, and ORNL. The official title could be the "ASEE-AECNSFORINSORNL Conference." The grant of funds from the National Science Foundation is dependent on the forthcoming action of Congress.

► . . . . That if you are 65 years *young,* have retired from active professional life, and have been in good standing for twenty-five years or more you may become a life member by vote of the General Council? Then you are exempt from the payment of dues. All you need to do is make a written request of the Secretary.

► . . . . That the Constitution also states you may become a life member by the lump sum payment of dues for twenty years? We have just discovered one such life member. Are there others? Are others interested?

► . . . . That a recent study disclosed that we have 62 living members who joined the Society in 1910 or earlier?

► . . . . That we need someone's help? A manuscript marked "(DRAFT)" with no name or other means of identification was sent to us. It is well prepared, typed, double spaced, edited in pencil, eight pages long, on Eminence Bond onion skin paper, and in the area of Engineering Science. If the author identifies his work we will be happy to consider it for publication in the JOURNAL.

► . . . . That copies of the report on the Humanistic-Social Research Project are now available from this office? Each of you will want to read it, just as you read the Evaluation Report. The cost is 25¢ per copy, 20¢ each in lots of 50 to 100, and 12¢ each in lots of 100 or more.

► . . . . That "Educational Aids in Engineering" are still available at $1.00 per copy? If you are in civil, electrical, or mechanical engineering, mechanics, or mathematics you should have a copy; many good ideas are presented. If you don't want a copy, does your library have one?

► . . . . That a copy of Educational Television Newsletter has been received? It tells of recent developments in various states and in various schools. However, there was nothing about courses in engineering. Has anyone been experimenting?

► . . . . That the *Proceedings* of the Society, since 1949, have been microfilmed? The work is done by University Microfilms, 313 N. First Street, Ann Arbor, Michigan and copies are sold by them to bona fide subscribers of the JOURNAL OF ENGINEERING EDUCATION at the end of the volume year, at which time the entire volume is delivered.

► . . . . That ECPD voted, "That the Council (ECPD) recommend to each constituent engineering society that they request each new member who joins a particular society to signify his acceptance of the Canons of Ethics, or of the code of ethics of the Society, as a condition of membership"? The Executive Board agreed that ASEE should not require new members to signify acceptance of a code. Most members accept such codes by virtue of membership in other societies; for non-engineer mem-

bers it does not seem desirable to have them agree to comply with an engineering code. They should, of course, know what the codes are.

► . . . . That it is a good idea for each of you to tear page 16 out of the 1956 Yearbook? Do it now! It is a membership application form, placed there for your use. Have it filled out by a cohort who is a non-member. Our present 8500 members represent only a small fraction of our potential! If you can't locate enough Yearbooks to meet your needs, we will be pleased to send you separate membership application forms—as many as you wish. Outstanding contributions already have been made, notably by W. D. McIlvaine of the University of Alabama, and by Wentworth Institute of Boston, Massachusetts. The former obtained many individual members, at least three associate institutional members, and contacted over fifty industries in his geographical area. Wentworth had 14 individual members and gained an additional 17. We congratulate both on their achievements! Are you doing your share?

► . . . . That the office staff wishes each of you a pleasant summer—of work, of vacation, or both?

W. LEIGHTON COLLINS
Secretary

MICROFILM EDITIONS OF THE ASEE JOURNAL AND PROCEEDINGS NOW AVAILABLE

The JOURNAL OF ENGINEERING EDUCATION, without advertisements, is now available through microfilm copies of the *Proceedings*, volumes 56–61. The microfilm is a positive copy furnished on labeled metal reels. Volume 56 (1948–49) is priced at $1.70; volume 57 (1949–50), volume 58 (1950–51), and 60 (1952–53) are $1.80; volume 59 (1951–52) is $1.60; and volume 61 (1953–54) is $2.00. Later volumes, at about $2.00 each, will be issued annually by University Microfilms, 313 North First Street, Ann Arbor, Michigan, from whom copies can be ordered. The availability of the JOURNAL in this form is an indication of its growing importance as a source of advanced and authoritative ideas on engineering education and research.

MECHANICAL ENGINEERS AND NUCLEAR POWER REACTOR DESIGN

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Second paper from the oral presentation at the ASEE session of the EJC Nuclear Engineering and Science Congress, this revised form has been prepared for the Atomic Energy Education Committee Conference of the 64th Annual Meeting on June 28, 1956.

Educational requirements for the nuclear engineer should not be considered as something unique. They are based on the same principles and concepts that underlie all branches of engineering. Nuclear engineering differs from the established fields of engineering mainly in its newness, and it is because of this newness, this lack of experience, that the nuclear engineer must rely on his knowledge of basic scientific principles, applied with engineering judgment. In most of its technical aspects, nuclear engineering education can, therefore, be integrated with the present trends of engineering education.

Typical Problem

To bring out the nature of the problem that faces the nuclear engineer, consider as typical the design of mechanisms to control a nuclear reactor. A reactor is a furnace in which heat is generated by nuclear fission. A control system must both regulate the nuclear reaction and provide for power changes or rapid shutdowns. Mechanisms may be used to transmit specified motions from mechanical drives (which are usually located outside a pressure vessel) into the region of the reactor core, where certain materials are moved to affect the nuclear reaction. The mechanisms must penetrate the pressure vessel, so that seals must be provided to maintain leak-tightness. Radioactive fluids must be kept in and contaminants must be kept out. The engineer must establish what leak rates are allowable. Different materials must be considered for porosity, possible radiation damage, possible chemical attack and temperature effects. Seal designs must be conceived and tested to meet the specific objectives of leak-tightness under conditions which realistically simulate service requirements. The pressure vessel must be examined at the penetration to assure leak-tight integrity and strength under a variety of loads including those due to pressure, thermal gradients and piping reactions.

Since the control motion is accurately specified in space and time, there may be a problem of dynamics to determine how the interaction of friction, mass and flexibility will modify the motion.

To guide the motion accurately, bearings must be used, which may function in possibly corrosive fluids, in regions of high temperature, and under nuclear radiation. Bearing wear must be investigated and the bearings must be proof-tested.

Materials and design configurations must be chosen to minimize leakage of nuclear radiation, and additional shielding added where necessary. In the case of replaceable parts, the

materials must not contain long-lived radioactive elements. Heat transfer problems in forced and natural convection or by steady-state and transient conduction must be solved, from which temperature distributions in critical parts can be determined. From these temperature distributions, thermal stresses and deformations must be evaluated in order to prove that the assembly will not malfunction as a result of thermal distortion or thermal stress fatigue. Finally, limitations on thermal and pressure stresses must be established for which commonly accepted construction codes may not apply.

After much preliminary study and testing of components, an overall design is at last determined. A prototype is then built which, along with previous component prototypes, serves to test the manufacturing feasibility. The design must be susceptible of fabrication at a reasonable cost and with available materials. This prototype is subjected to performance tests. Changes in the design are made as indicated by the test results and by the experience of the shop in producing the components.

The design of such components entails a knowledge of heat transfer, fluid dynamics, structural analysis, nuclear physics, metallurgy, chemistry, and manufacturing practices, and requires techniques of experimental and theoretical analysis. Most likely the team effort of mechanical designers and specialists is required. In this new field, an important concept involves the technical team of the mechanical designer, who possesses a broad understanding of the various fields, and of specialists, who possess depth of understanding in their particular field, as well as knowledge of specialized techniques.

At the Knolls Atomic Power Laboratory, these specialists may be called on to advise the designer in concepttual design in order to define and interpret design requirements. Theoretical and experimental programs of a highly specialized nature become the responsibility of the specialist. These theoretical evaluations may involve the use of analog or digital computers, network analyzers, flux-plotting equipment or special mathematical techniques, and may be in the fields of physics, chemistry or metallurgy, or in the engineering specialties, such as applied mechanics. The experimental investigations may be component testing employing radioactive testing techniques or may be experimental programs in support of theoretical evaluations. Other development testing is the responsibility of the engineer.

At the Knolls Atomic Power Laboratory, the engineer is assisted by semi-professional workers, who contribute to the projects as engineering calculators, in production and design follow-ups, as laboratory technicians, drafting designers, and specification and instruction book writers.

This problem typifies the demands of nuclear engineering. The designer must have a broad knowledge of fundamentals, primarily in heat transfer, structural analysis, nuclear physics and metallurgy. He must have a broad understanding of manufacturing practices to assist the shop in fabrication. He must make effective use of engineering experiments in order to prove that his design will function reliably under realistic operating conditions. He must rely on the advice of and cooperate with specialists to

evaluate special problems in theoretical and experimental analysis.

Although the problem of nuclear power plant design is basically related to that of any other engineering activity, significant differences exist, too. There is a higher premium on reliability in the design of basically new types of power plants. Accurate control of quality is necessary in order to compare the efficiencies of basic designs. Moreover, the potential hazards to operating personnel, the public, and property are much greater with nuclear power systems than with conventional power plants. As a consequence, the nuclear engineer must not accept usual design solutions and safety factors without careful examination. Manufacturers who furnish components are frequently asked to supply special information and to make special tests as assurance that their products can withstand particular service requirements. For instance, the nuclear engineer may think of leak-tightness in terms of mass-spectrometer leak tests, which is a relatively new concept for such large-scale components. Lacking service experience, the nuclear engineer must have a sound understanding of his service requirements and of scientific principles, so that he can correlate these requirements with equipment characteristics.

Educational Requirements

This discussion will consider undergraduate engineering training, assuming that specialization in any particular field will be reserved for the graduate program. The needs of the designer and specialist would be served by the same undergraduate curriculum, with the possible exception of a small percentage of electives coming in the senior year. From what has already been said, it is recommended that this undergraduate program should be basically in mechanical engineering with a heavy emphasis on fundamentals and on mathematical tools to use these fundamentals, including studies in modern physics. The student should be introduced to the practices and limitations of standard engineering measurements, including the use of thermocouples, strain gages, and other measurement techniques and devices. His mathematical training should stress utilization and include numerical analysis. Engineering problems as they apply to nuclear power plants should be incorporated wherever possible in the undergraduate work. Because the nuclear engineer must operate in a project organization, he must be trained in effective communication.

For the four-year engineering curriculum, a one-semester course in Nuclear Physics would be considered satisfactory. It is recommended that a good text in modern physics be used in preference to one covering only reactor theory. This is in line with the basic recommendation of teaching fundamentals where possible in preference to specific applications. Some thought should also be given to associating or comparing the principles of modern physics with those of classical physics and mechanics. For example, the Newtonian expression for kinetic energy can be shown to be an approximation of Einstein's mass-energy law.

It is recommended that the mechanical engineering course be weighted heavily with fundamentals. This would imply that applications should be taught mainly to assist in the understanding of basic concepts and

scientific principles, and to illustrate the engineering method. Courses like metallurgy should only include fundamentals, which will furnish a foundation on which the nuclear engineer can develop deeper understanding as new experience becomes available to him in his field.

Elective Courses Possible

Poincaré, the French mathematician and philosopher, observed [1] that it is impossible to study the works of the mathematicians without noticing two opposite kinds of minds. The one sort are all preoccupied with logic, and they apparently advance step by step in a problem solution. The other sort are guided by intuition, and they attempt to arrive at a solution with a quick but sometimes precarious stroke. Many of us may have observed similar tendencies in engineers. We might distinguish these two types as analysts and synthesists. In the development of many engineering components, the engineering is relatively simple, so that the arts of the synthesist, that is, the one who brings things together to create a design, and of the analyst, or the evaluator, are combined. Assurance that the design will operate successfully can be gained by relatively simple calculation, by testing, or by referring to experience.

In nuclear engineering, however, where experience is lacking, where testing is expensive, and where safety requirements and the high cost of repair due to radioactive inaccessibility put a high premium on reliability, the importance of analysis increases. This necessitates a high degree of analytical training and a knowledge of specialized techniques for engineering evaluation. It has been my observation that engineers tend to develop either as synthesists with broad information, or as specialists and analysts with detailed knowledge of a few particular fields, such as heat transfer or other branches of applied mechanics. I do not mean to infer that some engineers do not combine these talents. It is difficult, however, to find an engineer who becomes outstanding in both fields. It is possible that these differences in engineering function of the analyst and synthesist should be recognized by offering a small number of differently-directed elective courses.

Designs will be created primarily by the synthesists. The potential designer must be taught the creative approach [2] and should be given homework assignments which require exercising the imagination and extensive library work. An avid thirst for knowledge was one of Thomas Edison's traits. He read extensively in an attempt to keep up with technical advances both in this country and abroad. Homework problems requiring extensive library work are intended to introduce the student to the great reservoir of information available in libraries, government publications, and trade journals.

The analyst, on the other hand, will contribute to the project primarily as an evaluator of designs. He derives his creative satisfaction from synthesizing principles and techniques of mathematical logic, and would profit

[1] H. Poincare, *Foundations of Science,* translation by G. Halsted, p. 210, Science Press, Lancaster, Pa., 1946.

[2] See, for instance, "Developing a Useful Imagination," by E. K. Von Fange, *General Electric Review,* September 1955, p. 52; and "Solving Engineering Problems," by C. F. Hix and D. L. Purdy, *Machine Design,* October 1955, p. 242.

by being offered courses in higher mathematics as well as special techniques in numerical analysis.

Study of the Humanities

Engineering education for the nuclear engineer must also include studies of the humanities. Since nuclear technology produces effects on both a national and an international scale, those men who will eventually become leaders must develop a broad social perspective. The colleges can serve to establish a foundation upon which further development can proceed effectively.

Conclusion

I am grateful for the opportunity to express my views. That I have recommended a strengthening of the mathematics and basic sciences underlying engineering education is probably in agreement with most recommendations from industry, especially in the new fields of commercial application. It is my impression that these goals are mutually acceptable to engineers and engineering educators. The problem seems to be primarily in finding the best ways to achieve these goals as presently defined.

Furthermore, my recommendations do not by any means imply a five-year undergraduate program. I personally favor the four-year program as a satisfactory compromise not only for those who will be engaged in fields of engineering such as manufacturing and sales, but also for those who will eventually pursue purely technical development.

I recognize that engineering education is a dynamic activity, always seeking to improve. Much of this improvement will no doubt come by the experimental process and by investigation to see how various educational programs answer the needs of industry. I hope I have been able to add something to your information about the needs in nuclear engineering.

EDUCATIONAL REQUIREMENTS FOR TECHNICAL EDITORS

P. J. KALSEM

Engineering Division
The Glenn L. Martin Company
Baltimore, Maryland

TECH. EDITOR for large engr. firm M.E. Deg. required. Writing exp. or training not essential. Box 707.

This advertisement is typical of many attempts to fill a relatively modest, but persistent, demand for people who can write and edit technical material. Such advertisements reflect a tendency among employers to specify that technical editors must be engineering graduates. There are definite disadvantages, however, to restricting the source of technical editors in this way, for experience has proved that there are other desirable sources of such talent.

The pro-engineer side of the argument has been presented by Hamlett (1) of Sperry Gyroscope and by McDaniel and Scarlott (2) of Westinghouse. Their stand is backed by S. P. Olmsted (3) in describing the Rensselaer Polytechnic Institute graduate curriculum leading to a Master of Science degree in technical writing. This program is "based on the assumption that a full undergraduate engineering education, or an equivalent education in science, is a prerequisite to a career in technical writing." Rensselaer goes so far as to put out the "unwelcome" mat for certain liberal arts graduates: "No English majors need apply" (3).

But do engineers actually make the best technical editors? Are the personal qualities and training that make a man a good engineer the same ones that would make him a good writer or editor? I am inclined to doubt it, although I cannot point to extensive psychological studies of this problem. At any rate, the work of the engineer and that of the editor are substantially different, and it is reasonable to assume that the qualifications may also be different.

The engineer has basic responsibilities in analysis, design, or testing; to him, communication is an important but "sideline" activity in which he is seldom fully trained or experienced. His training and background have taught him to be adept, or most adept in communication via blueprints, mathematical equations, and graphs or charts.

The editor, on the other hand, is almost wholly engaged in the communication of ideas, with emphasis on the printed word and accompanying illustrations. As an editor, he must have enough background to *understand* the engineering ideas concerned, but his primary attribute is the ability to *communicate* them effectively to his readers.

In writing about the qualifications of technical editors, Dwight E. Gray (4), of the Technical Information Division, Library of Congress, states that a technical editor "should have had enough formal training . . . first, to give him an appreciation of science

and an understanding of the ground rules by which scientists operate and, second, to enable him to follow with reasonable intelligence the trend of thought in most of the reports that come to him for editorial diagnosis and treatment." This requirement certainly does not indicate the necessity for completing a full engineering or science curriculum as we know it today in most colleges.

The problem hinges partly on what industry requires of a technical editor. In many companies, the editor is considered an important part of the organization, and this is now reflected in the excellent financial opportunities available to him. Consider the typical case of an editor employed in the publications section of a laboratory or engineering department. If he has a true perspective, he realizes that his is a service function.

In one sense, he stands midway between the engineer-author and the reader, representing each to the other and serving the interests of both. In another sense, the engineer and the editor can be thought of as an entity: the efforts of both are combined to secure the most effective final result.

In a typical situation, the basic material is supplied by the engineer, generally in rough draft, and "writ by hand." Typical weaknesses in such rough drafts include incomplete summaries and introductions, poor arrangement of material, confusing paragraphs or sections, mistakes in grammar, inconsistencies in style, "deadwood" or wordiness, and lack of suitable illustrations.

To correct these weaknesses, the editor tackles the paper with his blue pencil, interviewing or challenging the engineer as needed. The rough draft is passed back to the engineer with editorial "improvements," some of which may not be satisfactory to the author. The material continues to be so exchanged for re-working and discussion until both engineer and editor are satisfied and, theoretically, the best interests of the reader have also been served.

Suppose, however, that the engineer and the editor are nearly identical in personal traits, and that both are trained as electronics engineers. Ideal communication would then exist between engineer and editor. The editorial process is relatively short and no one suffers, that is, no one except the neglected reader who more often than not will be a financial expert, engineering manager, or military administrator—without a technical background.

It is clear the reader would be better represented by an editor with broad training and knowledge, which includes not only editorial tools and engineering fundamentals but a knowledge of business administration, law, economics, and other social studies.

Also, in the case of progress reports and proposals, the author is not just one engineer, but a group of specialists in several different fields. Here again a broad background is advantageous to the editor. He must take writing with many individual differences, iron out the inconsistencies, and present a united front in the final effective product.

Examples of technical or semi-technical writing addressed to readers without extensive engineering training are numerous: over-all design summaries, progress reports, proposals for new business, documentary motion pictures, articles for submission to journals, oral presentations to administrators, training manuals and

handbooks. To such papers the editor with proper training can contribute a great deal; he can both complement the enginer and compensate for the engineer's weaknesses.

The less technical the reader, the greater will be the effort required of the editor. In extreme cases, the editor may do the entire writing job—basing it, of course, on interviews with the engineers.

At the other extreme, where an engineer is writing to fellow engineers (for instance, an aerodynamicist writing to other aerodynamicists on airplane drag analysis), the editor may merely supervise the report organization, style, and publication process—in many instances, a minor professional task.

Subject Knowledge Important

It is true, however, that a knowledge of the product or subject is important to a writer or editor. He cannot do a satisfactory job if he isolates himself completely from the engineer and the hardware. Yet, in his role of representing the reader, he need not know every detail known to the engineer; in fact, too much specialized knowledge of details may prove to be a handicap. At the Martin Company, our editors obtain this degree of firsthand product knowledge by working in the same physical location as do the engineers on a project, by attending project meetings, and by field trips to inspect customer activities.

What and Who?

What, then, are the best sources of technical writers and editors? Who can satisfactorily fill the editorial positions found in industry?

First of all, we must not discount the value of honest-to-goodness editors who have engineering degrees. But they should be engineers who have elected to study the written and spoken language and who are more interested in communicating by words and other publishing devices than by purely technical means only. Such training can be accomplished in a five-year undergraduate program and, to some extent, in the general engineering programs which have liberal policies on elective courses. If they do not have the benefit of military training, liberal arts majors who want to become technical editors should take a carefully chosen group of engineering and science electives.

A Utopian solution proposed by C. K. Arnold (5) is to establish a new curriculum that includes "basic training in the tools of both the editor and the scientist. . . ." Such a program might be administered either in engineering, or in a liberal arts or science department with the close cooperation of the engineering faculty.

Yet it is doubtful if the universities will add a new program of this type until (a) industry convinces them that there is a continuing demand for technical editors and (b) high school students, teachers and vocational counsellors, becoming fully aware of the opportunities, provide the required number and type of students. Further, it is possible to modify existing technical journalism programs to achieve the same objectives as the curriculum proposed by Mr. Arnold. Iowa State, for example, offers a minor sequence in journalism for engineers and an M.S. degree in engineering journalism.

To date, however, technical journalism programs have been slanted mainly toward the technical press and industrial advertising. These curric-

ula are almost evenly divided among three groups of subjects: (a) technical journalism, English, and other "communications" subjects; (b) specified physical and social sciences; and (c) electives or options.

These programs would also be useful in training technical editors if the electives were taken in engineering and if some of the journalism courses specifically took into account the more recently determined needs of industry. Typical programs that would be satsifactory are science journalism as offered at Iowa State and technical journalism as offered at Kansas State. These programs can provide not only basic editorial training, but sound schooling in the physical sciences and engineering—as well as a good knowledge of the social sciences. The latter is particularly helpful in compensating for the weaknesses of typical engineering personnel.

To get full value from these sources, industry and the universities should get together (a) to establish more clearly the requirements of industry; (b) to make the opportunities known to high school students; and (c) to determine the personal qualifications that make for success in this unusual combination of a science and an art.

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(3) Sterling P. Olmsted, "A Graduate Curriculum in Technical Writing." *Journal of Engineering Education*, March, 1955.

(4) Dwight E. Gray, "Editing Technical Reports." *The Production and Use of Technical Reports*. The Catholic University of America Press, Washington, D. C., 1955.

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EJC PROCEEDINGS

Discussions of the Reserve Forces Act of 1955, the balanced use of engineers and technicians, and the findings of the Hoover Commission are highlights of the material compiled in *Proceedings—Second General Assembly* of the Engineers Joint Council. The 68-page pamphlet contains not only the formal talks at the EJC General Council held in New York, January 26 and 27, 1956, but also reports the questions and discussions from the floor during the two-day conference. Details of the program are available in the December, 1955, issue of the JOURNAL OF ENGINEERING EDUCATION, page 412. The major issues and problems covered are of interest to the engineering profession today. The summary can be obtained from the EJC, 29 West 39th Street, New York, New York, for $1.00.

WHY DO ENGINEERS DISLIKE TECHNICAL WRITING?

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Why do engineers who produce such outstanding technical work do a poor job when writing about it? There are many theories; one says it is the fault of engineering education, another that the engineer himself has a bad psychological attitude toward writing.

This subject was discussed with engineers who do technical writing, and engineering executives were asked their opinions through a questionnaire.

The engineers who wrote generally said they didn't like to do so. Their reasons were varied, but in main were that they considered writing "busy work" of little importance, had never been properly trained in writing and found it confusing, and, accustomed to dealing with tangibles, found words and thoughts abstractions difficult to handle.

Engineering executives were chosen from both business and education. They all felt engineering writing was poor and agreed that engineering education did little in encouraging a student to write more effectively. Most executives questioned said technical writing comes hard because it is, in a sense, anticlimactic. Coming as it does after a project is finished, the engineer is impatient with writing up a past project and wants to get started on another problem.

A few executives mentioned that engineers are attracted to engineering in the first place because they have aptitudes in science and mathematics, and little liking for English. They can't see where writing proficiency will help them much in their chosen work, either.

A few men agreed technical writing was doubly difficult because the precise and constricted style necessary for accuracy is very boring. One man mentioned that companies employing engineers usually minimize the importance of technical writing. The majority of employees, he says, show actual contempt for "pencil pushing" and thus indoctrinate the already prejudiced engineer against technical writing.

In conclusion, it can be seen that the engineer's psychological barrier against technical writing must be removed before any improvement can be hoped for in his product. This can be done first of all in schools by offering courses in writing that stress how

interesting expressing yourself can be. If a student likes to write in the first place, professional and technical composition will come much more easily for him. Also, companies should realize the importance of well-written technical material and encourage in this direction, with praise and advancement, any employees who have training or aptitude for expression.

CIVIL ENGINEERING DIVISION-A. G. C. JOINT COOPERATIVE COMMITTEE

Following approval last November by the Executive Board and the General Council of the Society, the Association of General Contractors and the ASEE Civil Engineering Division have established a joint cooperative committee to consider problems of mutual interest. The first meeting will be held in the Memorial Union Building at Iowa State College, Ames, June 30, 1956. Typical problems scheduled for possible consideration are student and faculty summer employment, scholarship awards from industry, and methods to increase the supply of science teachers. Members of the committee are:

Acting Co-Chairmen

ASEE	A.G.C.
Frank W. Stubbs	W. A. Klinger

Acting Co-Secretaries

R. L. Peurifoy	Archie N. Carter

Committee Members

Paul F. Keim	Walter L. Couse
Arthur J. McNair	Arthur S. Horner
C. H. Oglesby	Manley Osgood
Harry Rubey	Howard H. Sturdy
W. W. Schenler	D. W. Winkelman

MICROWAVE ENGINEERING: HOW A NEW COURSE IS ADOPTED

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The following observations are based on the results of a survey conducted by the writer during 1954–1955 with a view to establishing the scope of college-level instruction in microwave (ultra-high-frequency) engineering, and making an estimate of the rate at which this important new subject has been entering the curricula of American engineering schools.

The survey was the outgrowth of an earlier one,[1] in which graduate curricula in electrical engineering were reviewed and certain educational trends were noted. In the earlier survey, some thirty electrical-engineering topics were listed by the various institutions as fields of specialization, but the answers could not be readily interpreted to provide any information regarding the degree of specialization or the development of the several subjects.

In the present survey, an attempt to obtain such information in a statistically significant form was made by selecting one of these subjects and making a detailed inquiry into its history and present status in engineering education. Many of the findings can be doubtless extended to apply to any engineering specialty, so that this procedure may be considered to be equivalent to a poll of a representative "sample" of engineering institutions. The subject selected for this particular sampling, microwave engineering, was picked partly because of the author's personal interest in it, but also because it represents a fairly new field—and yet one that has been with us long enough to become firmly established in the curriculum.

[1] G. R. Arthur and C. Süsskind, "Report on Graduate Curricula," *Proc. Inst. Rad. Eng.* **41**: 1952–3 (1953).

Institutions Polled

Questionnaires asking for information regarding courses and enrollments in the pertinent subjects, laboratory facilities, and textbooks prescribed or recommended, were sent to 152 institutions offering degrees in electrical engineering, of which 135 have curricula approved by the Engineers Council for Professional Development (ECPD). Fully 147, or 97 per cent, returned the filled-in questionnaires. A preliminary evaluation quickly showed that from the viewpoint of instruction in microwave engineering, each reporting institution could be readily assigned to one of three groups:

GROUP I: Several courses specifically devoted to microwaves, making up a considerable portion of the total electrical-engineering program. 10 institutions: Brooklyn Polytechnic Institute, California, Illinois Tech, Illinois, M.I.T., Michigan, Northwestern, Ohio State, Stanford, and Yale.

GROUP II: One or two microwave courses, usually with small enrollments, and constituting a relatively small portion of the over-all program.

62 institutions: Akron, Alabama Poly, Arizona, Arkansas, Brown, Buffalo, C.C.N.Y., Caltech, Cal. Poly, Cincinnati, Clarkson Tech, Colorado A. & M., Connecticut, Cornell, Dayton, Delaware, Drexel Tech, Fenn, Florida, Harvard, Iowa State, Iowa, Johns Hopkins, Kansas, Kentucky, Lafayette, Louisiana State, Loyola (L.A.), Maryland, Michigan M. & T., Michigan State, Milwaukee, Minnesota, Mississippi State, Missouri Mines, Missouri, Montana, New Mexico A. & M., New Mexico, Newark, North Dakota, Northeastern, Notre Dame, Ohio U., Oklahoma A. & M., Oklahoma, Pennsylvania Mil. Coll., Penn State, Princeton, Rensselaer, Seattle, U.S.C., Texas A. & M., Toledo, Tufts, Utah State, Utah, Villanova, Virginia Poly, Virginia, Washington, and Wisconsin.

GROUP III: No courses devoted entirely to microwaves. 75 institutions.

No Special Courses at Most Schools

The size of Group III is one of the more interesting results of the survey: more than half of the electrical-engineering departments in America have scheduled no courses comprising exclusively topics in microwave engineering. (This group includes, however, 11 of the 17 reporting institutions with curricula not approved by ECPD.) About half a dozen are planning to offer such a course within a year or two, and a few belong to universities at which sizable microwave programs are being carried on by the physics department (e.g., Alabama and Duke).

Virtually every school in this group has a place for microwave topics somewhere in its curriculum. According to replies to one part of the questionnaire, more than half teach the subject as a "predominant part of one or more electronics courses," either on the undergraduate or graduate level; most of the others teach microwaves as a "minor part of one or more electronics courses," and only a handful "not at all." There is some evidence, from replies to a question inviting comments, that several of the EE departments in Group III have deliberately avoided setting up a separate microwave-engineering course. The comments, which range in tone from apologetic to irascible (". . . do not approve such a division on a frequency basis—poor way to teach . . ."), make it obvious that not all the institutions in Group III are in this group solely because of a lack of facilities or qualified teaching personnel, although this appears to be the case for most of them.

Degree of Specialization

The remaining schools (Groups I and II) appear not only to have recognized the various advantages of teaching microwave engineering as a separate subject but—what is perhaps more important—were able to achieve this separation by virtue of superior facilities and larger budgets. It is certainly no coincidence that Groups I and II include a far greater number of the larger engineering colleges than Group III, which consists predominantly of smaller and less well-established institutions. The size and total endowment of the institution are not always the significant factors in this respect, to be sure; but the replies to a question asking for an estimate of the dollar worth of test equipment used in the instruction laboratories for (a) general electronics and (b) microwaves actually show that the EE departments of the schools in Groups I and II are on the whole

much better endowed than those in Group III.

Nevertheless, whether an institution falls into Group I or II does not appear to depend on size alone (though all schools in Group I have large enrollments and very good engineering facilities), but rather on several other factors that may or may not be the corollaries of large size, such as the availability of faculty members who have the training and the inclination to specialize in the particular subject, the extent of sponsored research in the department and elsewhere in the institution, and the history of the department (i.e., how soon the subject was established). A comparison of the institutions in the top group with those in Group II suggests strongly that the development of a highly specialized program in microwave engineering (and, by inference, in any other specialty) can be related to factors such as the above, and hence may be influenced to a considerable extent by departmental policy on employment, soliciting of research funds, and adjusting curricula to new demands.

The higher degree of specialization does not manifest itself solely in the larger number of courses devoted to the subject, but also in the manner in which the subject is taught. The present survey sought to obtain a measure of instructional sophistication by listing 10 textbooks on microwave theory and measurements and asking which of these (or any other) books are prescribed or used as references at each school. The same three standard textbooks (Brownwell and Beam, *Theory and Application of Microwaves;* Ramo and Whinnery, *Fields and Waves in Modern Radio;* and Reich, Krauss, Ordung, and Skalnik, *Microwave Theory and Techniques*)

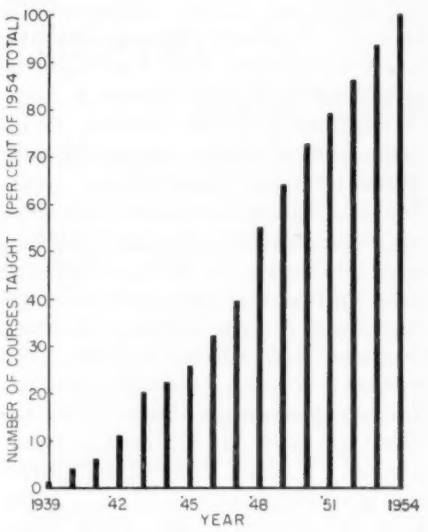

FIG. 1. Total number of courses in microwave engineering taught at Group I and II institutions, with 1954–55 as 100 per cent.

are most frequently prescribed at schools in both Group I and II, but the more advanced works, such as Montgomery's *Principles of Microwave Circuits* and Slater's *Microwave Electronics,* are more frequently prescribed *or* recommended in Group I institutions.

Rate of Adoption

Replies to the questionnaires did not yield reliable information as to which school in America was the first to schedule a formal course devoted to ultra-high frequencies, particularly since not all of the reporting institutions were in a position to state when each course was first given. The subject was doubtless taught as part of other courses very soon after oscillators in this frequency range first became available, in the late 'thirties. The first date to appear in the ques-

tionnaires is 1939, several years before microwave engineering could have been said to constitute a significant part of the technology. The most reliable measure of the rate at which the various institutions have been adopting microwave engineering as a separate subject since then may be obtained by tabulating the total (aggregate) number of courses taught in any given year. This information, based on starting dates for over 100 courses now being taught at Group I and II schools, is plotted in Figure 1, normalized to 1954–1955 as 100%.

It can be seen that adoption got off to a slow start, probably owing to military restrictions on the subject during the war years, 1939–1945, when most new work in it was being done at special industrial or government-sponsored laboratories rather than in engineering colleges. Since then, the total number of courses being given has climbed at a steady rate, and shows no sign of leveling off even after ten years. A further breakdown shows no significant difference in the rate of adoption between institutions in Groups I and II, although this finding cannot be considered to be wholly conclusive because of the small size of Group I (10 institutions).

One conclusion is incontrovertible, however: our engineering colleges are very much alive to the challenge of a changing technology. A new topic, such as microwave engineering, has every chance of being included in the curriculum as fast as the demand arises. In fact, the results of the present survey indicate that engineering schools sometimes anticipate the demand and actually provide instruction in a new field even before it has had time to develop technologically, thus fulfilling their exalted function of leading in the progress of our civilization, rather than merely following the lead of others.

ON TEACHING PHYSICAL MECHANICS

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Based on a paper given at the joint meeting of the American Society of Engineering Education (Physics Division) and of the American Association of Physics Teachers at Pennsylvania State University, June, 1955.

As a college student I took a mathematics course called "Analytical Mechanics." Such a title, I suppose, suggests an emphasis on an algebraic approach to mechanics somewhat in the tradition of L. Euler's "Mechanica, sive Motus Scientia Analytice Exposita" (1736) and of J. Lagrange's "Mécanique Analytique" (1788), as contrasted with the synthetical (geometrical) approach in I. Newton's "Philosophiae Naturalis Principia Mathematica" (1686). You may recall that Lagrange even boasted in his preface that "there are no figures in this work." Who among us, indeed, has not experienced a thrill in realizing the beauty of theoretical mechanics and the power of its analytic techniques! Mechanics, including celestial mechanics, is both the oldest and the most highly developed of the physical sciences—one of man's great intellectual achievements.

Physical mechanics,[1] as I use the term, is not this analytical (or rational) mechanics [2] as understood by the mathematician, nor is it applied mechanics [3] as used by the engineer (although I would certainly illustrate physical principles to some degree with concrete applications from engineering, as well as from astronomy and physics). It is interesting to compare J. L. Synge's [4] definition of mathematical physics: "The creation of a coherent mathematical theory with assumptions clearly set forth is the primary object, physical interpretation in terms of experiment being relegated to a secondary position." I would argue that this type of course might better be termed applied mathematics. It is certainly not physics, which must always be rooted in phenomena. His other category termed "naturalistic physics" seems etymologically confusing, but more akin to my concept of physical mechanics. In his lectures on "Partial Differential Equations in

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[3] H. F. Girvin, "A Historical Appraisal of Mechanics" (1948). G. W. Housner and D. E. Hudson, "Applied Mechanics" (1950). J. L. Meriam, "Mechanics" (1952). A. P. Poorman, "Applied Mechanics" (4th ed., 1940). J. L. Singer, "Engineering Mechanics" (2nd ed., 1954).

[4] J. L. Synge, "Geometrical Mechanics and de Broglie Waves" (1952).

Physics" A. Sommerfeld notes: "We do not really deal with mathematical physics, but with physical mathematics; not with the mathematical formulation of physical facts, but with the physical motivation of mathematical methods." M. Born properly concludes his "Experiment and Theory in Physics" as follows: "My advice to those who wish to learn the art of scientific prophecy is not to rely on abstract reason, but to decipher the secret language of Nature from Nature's documents, the facts of experience." From the viewpoint that physics is essentially the creative product of a physicist, physical mechanics stresses the critical understanding of mechanical phenomena by the scientific method, including the limits to which its successes can be extended to other phenomena. Through necessarily slow social acceptance, the science of yesterday becomes the common sense of today and, as such, appears to be self evident. First courses in mechanics, accordingly, are peculiarly susceptible of being taught from a dogmatic and over-simplified point of view. The present theories of motion, on the contrary, have not always been accepted. As late as 1915 even E. Mach remarked, "I do not consider Newtonian principles a completed and perfected thing." One must recognize the challenging frontiers of yesterday in order to be alert to the challenges inherent in the obvious of today. For example, the equivalence of gravitational mass and of inertial mass was regarded by many as a happy coincidence until A. Einstein saw in this fact a fundamental relationship between gravitation and matter.

In approaching physical mechanics as an endless frontier of research and education,[5] therefore, I would emphasize: (a) an operational[6] point of view with respect to the world of (classical) mechanical phenomena; (b) the physical use of mathematics[7] with respect to the world of mathematical concepts; and (c) the mechanistic philosophy[8] of matter with respect to the world of physical theory.

Let us consider, first, the operational point of view with respect to the world of mechanical phenomena (less valuable in atomic phenomena where physical quantities are not

[5] R. J. Seeger, "On Fluid Dynamics in Physics Teaching," *Amer. Journal of Physics, 21,* 29 (1953); "On Education, Engineering and Physics," JOURNAL OF ENG. EDUCATION, *44,* 285–80 (1954); "Physics Is Not Engineering," JOURNAL OF ENG. EDUCATION, *46,* 127 (1955); "On the Liberal Sciences," *Journal of The Washington Academy of Sciences, 45,* 361 (1955).

[6] P. W. Bridgman, "The Logic of Modern Physics" (1928); "The Nature of Physical Theory" (1936); "The Nature of Some of Our Physical Concepts" (1952). H. Poincaré, "The Foundations of Science" (Eng. ed., 1913). R. J. Seeger, "Beyond Operationalism" (*The Scientific Monthly, 79,* 226–27, 1954).

[7] M. Black, "The Nature of Mathematics" (1933). R. Courant and H. Robbins, "What Is Mathematics?" (1941). R. Courant and D. Hilbert, "Methods of Mathematical Methods" I (Eng. ed., 1953). A. Sommerfeld, "Partial Differential Equations in Physics" (Eng. ed., 1948). A. N. Whitehead, "An Introduction to Mathematics" (1911).

[8] E. A. Burtt, "The Metaphysical Foundations of Modern Physical Science" (Rev. ed., 1932). H. Butterfield, "The Origins of Modern Science" (1951). L. de Broglie, "Physics and Microphysics" (Eng. ed., 1955). H. Dingle, "Through Science to Philosophy" (1937). A. Einstein and L. Infeld, "The Evolution of Physics" (1938). G. Gamow, "Mr. Tompkins in Wonderland" (1940); "Mr. Tompkins Explores the Atom." J. C. Slater, "Modern Physics" (1955). R. von Mises, "Positivism" (1951). A. N. Whitehead, "Science and the Modern World" (1928).

accessible to direct measurement). Any physics course, I would again urge, must be kept intimately related to observations, particularly quantitative ones. In making measurements we are at once confronted with three primitive concepts, *viz.*, length, time, and mass.

The student should be introduced to the range of values for these quantities actually measurable in nature, viz., distances from $(10)^{-13}$ cm. for a nuclear radius to $(10)^{27}$ cm. for the distance to the farthest galaxy, times from $(10)^{-10}$ sec. for a nuclear lifetime to $(10)^{11}$ sec. duration between known ecliptic measurements to $(10)^{16}$ sec. for estimated age of the universe; masses from $(10)^{-27}$ g. for an electron at rest to $(10)^{35}$ g. for a star. He should be encouraged to wonder at these particular values and to have some appreciation of the different techniques employed to cover these gamuts.

Take first the concept of length. I am using this term not as an *a priori* category, but rather as an experience in physical or public space—not in private or individual space, nor in mathematical or conceptual space. What do we mean by the length of a familiar object, say, the length of an iron rod? Let us measure it in terms of some arbitrary unit. Evidently the answer we obtain depends upon the physical conditions of the rod at the time of measurement: its temperature, the gravitational field, the electric field, the magnetic field, *et al.* All that we mean physically by the length of such a body, then, is the answer we get in following certain prescribed procedures of measurement under specific physical conditions. The procedures, moreover, may be quite different, as in the case of a length like the distance from the earth to the moon. To determine the distance to the moon one employs essentially the method of triangulation familiarly used with a surveyor's theodolite. Because of the inaccessibility of the moon, however, we must supplement direct observations with some theoretical interpretations. For example, the calculations depend upon the optical laws involved in the propagation of light and upon the geometrical theorems applied. This method of length measurement, therefore, is operationally different from the one previously used. What about the resulting concept of length? Is it the same in each instance? Let us regard still another case, say, the diameter of an electron? Here we not only have no method of direct observation, but we cannot even see the object. Our method of measurement, therefore, is still more indirect. Now we have to rely on the use of electromagnetic theory with its complicated effects for high-speed motion. Hence we have distinctly a third operational procedure. Strictly speaking, these three different methods of measurement imply three different concepts of length. It is only because of their equivalence under the same limiting conditions that we are justified in postulating a common concept of length. It is not that the length of any body ever changes but rather that different methods of measurement may be used so that one seeks to obtain a value for the length satisfactory for all (the restricted theory of relativity postulates this invariance for systems moving uniformly relative to each other).

It can be shown that the postulate of the constancy of the speed of light in vacuo for systems moving uniformly relative to each other demands

that the measured length of a rod moving lengthwise be less than that of the rod at rest. Hence in relativistic mechanics a rigid body takes on different characteristics which can no longer be described by ordinary Euclidean geometry. For example, the ratio of the circumference of a uniformly rotating disc to its radius is equal to 2π only for a small radius, where the linear speed is small with respect to the speed of light, so that a disc cannot generally be regarded as a Euclidean rigid body in the classical mechanical sense. By assuming non-Euclidean axioms, however, we can make a new definition of a rigid body which reduces to the familiar one for small speeds (i.e., in the limit for zero speed).

We find a similar problem presented to us in the case of time. Even the seemingly self-evident concept of simultaneity is found to be fraught with difficulties which stem from the finite, constant speed of light which is found to be independent of the relative motion of observed and observer. Just as rods appear to be shorter if measured when moving than when at rest, so clocks seem to be slower when moving as compared with their readings when at rest. Thus even obvious concepts like time and length need to be examined carefully from a modern operational point of view.

We recall, moreover, that ever since the day of Descartes, who reduced Aristotle's primary qualities to extension in space and duration in time, description of matter and motion has been formulated in these terms, together with the concept of mass, which is involved in the fundamental laws of motion.

Newton's laws of motion have been regarded by some as conceptual definitions and by others as experimental facts. In view of the complex nature of modern theory, it is probably preferable to regard them somewhat like axioms in geometry (as an earth science) and to speak of them as principles of motion. The impracticability of giving direct descriptions of observed phenomena today necessitates such a formal (axiomatic) system with indirect descriptions. The laws of motion are to be regarded then as essentially free creations of man's mind; they are not uniquely determined by the world of phenomena. From these axioms, of course, one can make formal deductions in accordance with logical rigor—what might be properly called analytical mechanics. It is evident, however, that such a process would be physically meaningless without some relations between the ideal concepts and the actual phenomena; i.e., without operational significance. From this point of view let us consider each of the laws of motion.

Galileo arrived at his conception of inertia by watching the motion of a ball on a smooth, inclined plane. When the plane was inclined upward, the ball would stop; when it was inclined downward, the ball would accelerate. It was natural to suppose that for an infinite, horizontal (normal to the earth's gravitational field) plane without friction the ball would continue to move without a change in velocity. It was actually Newton who first formulated the generalization of this experience as we know it today. The first law of motion is not insignificant as some have supposed; rather it is actually the most fundamental and, hence, rightly first. The law appears simple; but it is quite complex. It states: "Every material body remains in a state of rest or of uniform

rectilinear motion unless compelled by forces acting on it to change its state." In a current popular text on applied mechanics, we read this interpretation of the law: "We define force by Newton's first law as an action which tends to change the motion of a body." This anthropomorphic conception of force is typical of the attitude found in many engineering texts. A physicist would certainly object at once to any such negative statement being a positive definition. This first law may well describe vaguely a state without force; this fact, however, does not enable one to characterize precisely a state with force. Newton's own statement, indeed, is physically meaningless without specifying just how one recognizes an unbalanced force, or rectilinear motion, or even a state of rest. In other words, this statement of the law is predicated upon a physical system of reference. Is the earth such a proper system? J. L. Foucault's pendulum experiment showed that the earth is changing its position relative to that of the pendulum, and hence to the fixed stars. How about the fixed stars themselves? Would they serve as a physical system of reference? Here, too, we now recognize proper motions even in "fixed" constellations. Strictly speaking, we can regard the earth as a system of reference in a first approximation; the fixed stars as such a system in a second approximation, etc. In this way we may define an ideal "inertial system," which represents an arbitrary formal (logical) convention, and which, in turn, will be practically useful only if it can be identified operationally. The law of inertia itself, however, does not tell us how to identify such an inertial system.

Newton's second law of motion states that "The change in motion [momentum] is proportional to the force acting and takes place in the direction of the straight line along which the force acts." In the above-quoted text one finds this interpretation: "The concept of force is made quantitatively precise by the definition that a unit force produces unit acceleration of a specified standard body . . . the mass of a body may now be defined by Newton's second law as the ratio of the force acting on the body to the resultant acceleration." It is evident in any case that a single relationship between force and mass cannot be used quantitatively for the definitions of both. One can express the so-called law of acceleration by the following equations.

$$F = km\ a,$$

or

$$F = ma, \text{ for } k = 1,$$

where F signifies the unbalanced force, m the mass of the body (or system), a its acceleration, and k a constant of proportionality. This form of the law is restricted to constancy of mass; the more general statement involves time-rate of change of momentum. We note that an inertial system is required here, too, for the operational specification of acceleration (i.e., acceleration with respect to what body or system?). If one can measure all three quantities independently, one then has an experimental law. It was first suggested by G. Kirchhoff that force should be regarded as merely a name for ma; it was later emphasized by H. Poincaré that this definition itself is purely a conventional matter. In any case the statement is physically meaningless without an operational definition of force, too.

For a constant force, one finds the well-known formula that $s = \frac{1}{2} gt^2$ for the distance s traversed by a body starting initially from rest at some point in a uniform gravitation field chosen as the origin (g is the acceleration due to gravity). If the gravitational force on a body varies inversely as the square of its distance from a fixed point of attraction we find that the orbit is elliptic. Newton's law, of course, can be applied also to electric and magnetic forces. In any case, the path of motion is determined by integrating the equation of motion, which is all important. In general, by specifying the force F as a function of the coordinates, Newton's second law gives the acceleration of a body "simply" with respect to the coordinates, i.e., for a given inertial system. The structural content of the second law, therefore, is not specifically $F = ma$ (or generally $F = d/dt(mv)$), but rather the acceleration a as a function of the coordinates. Some individuals have spoken of a fourth law of motion (actually given as a corollary by Newton) in that each of several forces, acting simultaneously on the same body, is independent in causing the resultant effect, which can be determined for all by vector addition. For zero acceleration, of course, one obtains the well-known principle of conservation of momentum by integration with respect to the time. The principle of conservation of mechanical energy, in turn, follows from spatial integration of the general equation.

"Action always equals reaction" is the simple, but easily misunderstood, statement of Newton's third law of motion. Specifically, it means that the acceleration of a body does not occur alone in nature, but always in association with the acceleration of at least one other body—action of one body on another body and the reaction of the latter on the former. (This law, accordingly, determines the entire field of structural statics—rarely mentioned in engineering texts.) Let us examine its general significance.

First of all, it is the third law that makes possible an operational definition of mass—not the second law. For example, in the case of two bodies acting upon each other, one observes that the ratio of their acceleration is constant, independent of the force involved or of the velocities of the bodies, *et al.* This constant may be expressed as the ratio of two other constants, each of which is peculiar to its respective body, and which, therefore, may be regarded as its mass (determined uniquely for an arbitrary "standard" mass). This mass is independent of external circumstances; it may be regarded as a measure of the body's inertia. The product of the mass and acceleration, on the other hand, is independent of the body itself and thus may be looked upon as a measure of the external force on it. The operational definition of mass together with this operational definition of force (ma in terms of the coordinates), and with the operational definition of acceleration, makes the formal statement of the second law actually descriptive of mechanical phenomena and hence truly a physical law of nature.

The physics of the problem consists primarily in the formulation of the equation, including some mathematical guessing, and in the recognition of appropriate conditions to be satisfied by the solution—the rest is technical mathematics. One must be careful to distinguish physical essence from various modes of mathematical rep-

resentation. The number of specific physical conditions must equal the number of such arbitrary quantities for a real physical solution to the problem.

Secondly, if one considers large velocities, one finds it convenient to express the second law as an increment of the speed Δv proportional to the increment of time Δt involved thus:

$$\Delta v = (F/m)\,\Delta t.$$

For constant force F the speed v would increase without limit, which is contradictory to the principle of restricted relativity. In this case, therefore, the ratio of force to mass must simultaneously decrease in order that the speed v remain always less than the speed of light. In other words, the measured mass cannot be constant; it must necessarily increase with speed—and is actually observed to do so. Here we are likely to be confused by our own naiveté that mass is a measure of quantity of matter. We need a new operational definition of mass, which will agree with the older, simpler concept for small velocities, the latter mass being usually called the "rest mass" m_0 for the limit of zero speed. What is more, the ratio of the force on a body to its acceleration is observed to vary with the relative directions of the force and of the velocity of the body: for example, the measurement of the force transverse to the motion of a body is different from that obtained parallel to it. The vector sum (mv) of all momenta for interactions within a system is found to remain constant only for the transverse measurement, provided there are no external influences. Accordingly, in order to preserve the principle of conservation of momentum, one chooses now the transverse measurement F/a as a new operational definition of mass. This new mass, called the "apparent" or "relativistic" mass, is related to the rest mass as follows, for v is small relative to c:

$$m = m_0 + \frac{\text{Kinetic Energy}}{c^2},$$

where c is the speed of light. Because of its relation to the original ratio $m = F/a$, the relativistic mass can be regarded as a possible successor to Newtonian constant mass m_0. If we observe uranium fission, however, we observe an increase of the kinetic energy of the nuclear fragments with a corresponding decrease of the total rest masses—the sum of the apparent masses remaining constant (principle of conservation of mass). Hence we find ourselves now preferring relativistic mass as a new operational definition inasmuch as more theorems of Newtonian mechanics will be unaffected by this choice.

The idea of a system with variable mass, to be sure, is not restricted to relativistic considerations. In the previously cited text one reads, "It is important to note that Newton's second law refers to a specific body and does not refer directly to a system which is losing or gaining material." This statement itself is somewhat loose in more ways than one. In the first place, is one thinking of a rigid body or of a deformable body? Secondly, let us consider a system like a sprinkler wagon or an interplanetary rocket with continuous exhaust. In applying Newton's second law we can either add to the change in momentun contained in the body the momentum convectively added or given off per unit time, or we can regard the recoil

momentum gained or lost per unit time as a kind of external force. In either case, the second law of motion will certainly be applicable to this system losing (or gaining) material; the mathematical terms, however, have to be interpreted physically.

Inertial systems as now understood refer to systems moving uniformly relative to each other, for which Newtonian mechanics holds in its relativistic (restricted) form. The problem of formulating physical laws for every coordinate system has been solved by the theory of general relativity. The fact that inertial mass and gravitational mass are equal is here regarded as fundamental—not accidental as in classical mechanics. It would take us too far afield to develop this concept here. Suffice it to indicate the connection in an idealized experiment with an elevator. From the top of a super-skyscraper the supporting cable of an elevator breaks—unknown to the occupants, who are observing that a freely "falling" ball and pen behave in accord with the principle of inertia. To an outsider looking through a window the phenomena are also in agreement with Newtonian motion in a gravitational field. The equivalence of gravitational and inertial mass makes possible two different but consistent descriptions of the same phenomena for two systems that are not moving uniformly with respect to each other. Let us consider another idealized experiment, say, a cable lifting the elevator with constant force and hence constant acceleration. The ignorant observer inside would probably ascribe the "falling" of all bodies to the elevator's floor to a gravitational field, whereas, the outside observer would describe the same phenomenon as due solely to inertial behavior independent of any gravitational force. Einstein's principle of equivalence demands that every motion relative to an accelerated system behaves like a motion relative to an inertial system in a gravitational field. As in Newtonian relativistic mechanics there is no absolute speed (and hence translation), so in Einsteinian general relativity there is no absolute acceleration (and hence rotation). A pure field physics, however, is still unattained. Physical mechanics must continue to differentiate generally between matter and field. A physics student, at any rate, must learn early how the laws of mechanics are modified by relativity, which arises from field problems.

Let us now turn our attention to the world of mathematical concepts. We should always bear in mind that much of mathematics analysis has been invented specifically for describing physical phenomena: for example, the use of certain infinite series to solve practical problems in heat conduction. J. B. Fourier himself said, "Profound study of nature is the most fertile source of mathematical discoveries." The physicist has found it profitable not merely to watch the totality of phenomena like the moving water of a river, but rather to examine causally the behavior of very small portions for very short periods of time. Thus he sets up differential equations involving rates of change and then solves (integrates) them as functions of the time for comparison with the phenomena themselves.

The physicist is concerned primarily with the formulation of the physical problem in mathematical terms; the mathematician is responsible for interpreting the mathematical significance of the resulting equations. The differ-

ential equation by itself expresses only the general law for a physical phenomenon. A specific physical problem requires also initial or boundary conditions, which determine the arbitrary constants or functions that occur in the integration of the differential equation.

In the case of so-called ordinary differential equations, involving ordinary derivatives of a single independent variable, one considers generally a system with a finite number of degrees of freedom and with time as the single independent variable—for example, a single ideal system like a particle or a rigid body. The use of the derivative in describing the motion of such an object is based upon the assumption that the limit of the quotient of small increments of physical variables exists, which, in turn, is predicated upon the idea of a continuous function, for example, velocity $Lim_{\Delta t \to 0} \Delta s/\Delta t$. Position and velocity, however, are not sufficient to describe the motion of a body completely; as we have noted in Newton's laws, acceleration is also needed. This second-order derivative, moreover, has been found adequate so that higher time-derivatives are not required. Hence the equations of motion are second-order differential equations in time. A good illustration is so-called simple harmonic motion, as in the case of a spring with a particle attached and with a restoring force given by Hooke's law, i.e., the force is proportional to the displacement of the particle from its position of equilibrium and directed toward that position. In our everyday world such motion finally ceases. Accordingly, we must add a damping term, which is found to be proportional to the velocity. Furthermore, the restoring force for an object like the ear drum may require the addition of another term quadratic in the displacement. Furthermore, a twisted fiber requires the addition also of a "hereditary" term. In general, an ordinary differential equation relates the behavior of a particle here to an influence there, i.e., widely separated events. Its solution gives the history of a material particle at some later place in terms of its characteristics here and now. Sometimes ordinary differential equations occur in physical problems (e.g., the bending of beams) as a degenerate mathematical form due to the neglect of all but one independent variable.

In partial differential equations, involving a function of several variables and its partial derivatives, one is concerned with a system with infinite degrees of freedom and with independent space and time variables—for example, a continuous medium. An introductory mechanics course, I believe, should deal with such systems of an infinite number of degrees of freedom [5] as well as with systems of a finite number of degrees of freedom. A partial differential equation describes the state of such a system "here and now" in terms of the immediate neighborhood just a little while ago. Its solution gives the history of the whole field later in terms of its characteristics all over now. Moreover, one uses field quantities, defined at such point-space as function of time; hence there are usually four independent variables for partial differential equations of physics. Here assuming that the physical quantities are continuous functions of the coordinates and of the time, by a Taylor expansion in the neighborhood of equilibrium and by neglect of higher-order terms, one finds as an expres-

sion of the principle of conservation of mass the so-called equation of continuity, a first-order partial differential equation. The further assumption of a velocity function for an incompressible, homogeneous medium results in the Laplace's second-order differential equation (spatial). Likewise the equation of motion reduces to a first-order partial differential equation. If one assumes also that the displacements, the corresponding velocities, and their rates of change are negligible to the extent that powers of them higher than the first are all relatively negligible, one obtains the well-known wave equation, a second-order partial differential equation in time and space. Its linear character signifies the principle of superposition of waves. It should be noted, however, that shock waves can be described without the assumption of continuity by a direct application of the conservation principles. They represent non-linear phenomena without any evident rule for superposition.

Whereas arbitrary constants expressing initial values are adequate for the complete solution of an ordinary differential equation, arbitrary functions are required for the general solution of a partial differential equation. (Differentiation enables one to eliminate particular constants and to obtain a more general description, whereas integration involves specific knowledge for describing actual physical phenomena.) A solution of a partial differential equation in variables is usually sought over some n-dimensional domain. Often conditions are imposed over an $(n-1)$ domain. For example, in the case of a typical "initial-value" problem with two variables the initial values of amplitude and velocity along an open curve must be specified at an initial time in order to obtain amplitudes and velocities for all future times (cf. wave phenomena). In the case of a typical "boundary-value" problem, however, values of the functions and its derivatives along a closed curve, independent of time, are required for determining the nature of a regular function within the curve (cf. equilibria phenomena). Fixed points on a vibrating string and quantum conditions behave virtually as boundary conditions in selecting particular functions, i.e., those with certain frequency values. Why in certain problems, however, does one need initial values and why in others boundary conditions? In general, one finds that these mathematical conditions are required in order that we may obtain a so-called reasonable solution, namely, one mathematically useful for interpreting a physical process. On the one hand, mathematics must not impose so many restrictions that no solution at all can satisfy them; on the other hand, the restrictions must not be so few that no unique solution is possible. Finally, the solution must depend upon data continuously, so that small data changes, inherent in necessarily approximate measurements, cannot produce large changes in the resulting solutions. The use of modern high-speed calculating machines for the numerical analysis of differential equations has introduced a new era for the physical use of mathematical concepts. Problems can be solved today which were impractical a generation ago.

One more note on the physical use of mathematics! It is highly desirable that a physical law should be independent of the particular coordinate system describing it. The physical quantities involved, therefore, must

transform in similar ways, i.e., they must be represented by tensors. Unfortunately tensors, which are represented by second degree surfaces (cf. the ellipsoid of inertia), are less concrete and, therefore, seemingly less intelligible than vectors, which represent line segments. Here again, we see that the general form of the law may be as important physically as its specific content.

Let us now consider the development of mechanistic philosophy with respect to the world of physical theory. In other words, what is the scope of theoretical mechanics and what is its limitation, particularly in the world of theoretical physics? Newton's laws of motion are remarkable in that they are still valuable in their original form (operationally interpreted) for describing mechanical phenomena—partially because their accuracy makes them useful, partially because their simplicity renders them teachable, and partially because their naturalness makes them socially acceptable (due to their close analogy with the very phenomena). It would be unfortunate, however, in a world of modern physics for students to be indoctrinated with the idea that Newton's laws of motion, which were formulated almost 300 years ago, are the last word even on the subject of mechanics itself. There have been more recent formulations of mechanics which have enabled man to deepen his understanding of the known relations. For example, in 1743 J. D'Alembert enunciated a principle by means of which dynamical phenomena can be treated from the standpoint of equilibrium, i.e., from the standpoint of statics. Using the concept of force he was able to express the laws of mechanical motion in a single formula with grace and elegance—a remarkable example of economy of thought. Subsequently, J. Lagrange derived equations for any physical system in terms of generalized coordinates, particularly valuable in cases of acoustical, optical, and electrical phenomena, where particles may not even be observable. Later W. R. Hamilton discovered a canonical form of the basic equations, which have the valuable property of remaining invariant with respect to certain theoretical types of coordinate transformation. It would seem desirable in any physics course to outline the historical perspective of mechanics from its primitive concepts to these more abstract ones.

More radical views, however, have been introduced by others. Starting with the intuitive principle of least action in 1747 by P. L. Moreau de Maupertuis, Hamilton introduced a more general one in 1824. He found it possible to describe mechanical phenomena in terms of the stationary values of an integral involving an energy function. This integral does not require a knowledge of the forces themselves; moreover, it is independent of the coordinate system employed. The principle is applicable to the classical mechanics not only of particles and of rigid bodies, but also of deformable bodies and fluids—not to mention field theories (electromagnetism, electron, proton, meson). The principle thus has a highly significant economic descriptive value in that it epitomizes so many different areas of phenomena. Another novel idea was introduced in 1829 by C. F. Gauss in his principle of least constraint. Here one requires the knowledge of neither force nor energy, only the criterion that the system should move as freely

as possible with respect to certain constraints that are necessitated because of the impressed forces. A more abstract generalization of this principle was made in 1894 by H. R. Hertz, who proposed a principle of straightest path. Avoiding the concepts of mass, force, and energy he succeeded in reducing dynamics to kinematics by means of certain concealed motions of particles. The system can thus be regarded as virtually in a state of rest or of uniform motion. Let us turn now from these abstract theories to concrete applications, particularly in other physical phenomena.

As emphasized by E. Mach, "Purely mechanical phenomena do not exist." They are "abstractions, made either intentionally or from necessity, facilitating our comprehension of things." A. Einstein has stressed that "it is impossible to divide science into separate and unrelated sections." Newton himself applied the laws of mechanics to the analysis of fluid motions, including acoustical phenomena. He was able to account for compression waves in fluids and solids. It is significant, indeed, that he believed the laws applicable to all motions, mechanical or otherwise.

In 1738 D. Bernoulli extended the realm of mechanics to account for the pressure in gases in terms of the motion of particles. It was J. P. Joule, however, who in 1851 related this molecular motion to the thermal energy of the gas. Subsequently, the kinetic theory of gases was further extended to explain phenomena such as viscosity in terms of transport of momentum, diffusion in terms of transport of matter, and heat conduction in terms of transport of energy. Statistical mechanics *per se* is undoubtedly beyond the scope of a course in physical mechanics. The general area of its scope and validity, however, should be pointed out to beginning students.

The conservation of mechanical energy is obtained from spatial integration of the equations of motion. In general, it is inadequate for a complete description of mechanical phenomena except in the case of a system with one degree of freedom, which has only one equation of motion. So-called conservative systems comprise a useful class for theoretical analysis of mechanical phenomena. In the case of non-conservative systems the realization that heat can be regarded as a mode of motion has made it possible for certain of these, in turn, to be described in mechanical terms. It is significant that such concepts as electrical energy, *et al.*, are operationally meaningless today except in mechanical terms. The success of mechanism in enabling one to understand any physical phenomenon was largely responsible for the belief of individuals like H. von Helmholtz and Lord Kelvin that no physical theory itself can be successful unless it has a mechanical basis.

Subsequently physicists have become more aware of the limitations of mechanism in theoretical physics. I shall not attempt to develop here the rise and decline of the mechanical view in the realm of electrical and optical phenomena—not properly physical mechanics. Suffice it to note certain aspects of modern particle physics. In the first place, although the position and velocity of molecules are determinable in principle, from a practical viewpoint there always exists an ignorance of initial values. Hence probability considerations and statistical methods must be introduced to

supplement the conservation of energy in thermodynamics with the so-called second law of thermodynamics, which is statistical in character (cf. Brownian movements from which the mass of a molecule can be determined).

The development of wave mechanics in quantum physics seemed at first likely to extend further the applicability of mechanics to physical phenomena. Here however, the ignorance of initial values presents a difficulty inherent in the very phenomena (cf. the uncertainty principle), because the simultaneous determination of position and velocity of a particle like an electron with increasing precision is not possible even in principle. Hence quantum mechanics itself has had to be interpreted statistically to preserve the law of causality for theoretical concepts and at the same time to relate them to the world of phenomena.

In nuclear physics, too, one learned early of the limitations of mechanics in describing phenomena like radioactivity. Here the number of particles emitted from nuclei is found to be proportional to the number of nuclei and to the duration of observation. The number, however, is observed to be independent of the velocity, the mass, the force, or the energy of the particles. Once more we are confronted with the necessity of introducing probability considerations. It is necessary to add that the whole question of the nature of elementary particles is becoming increasingly complex and confusing, not to mention their relation both to fields, and to the understanding of matter itself. In the face of these phenomena one wonders about the validity of the assertion in the above mentioned text that "All observations subsequent to Newton's time are in agreement with them" [Newton's Laws].

In conclusion, it is evident that physicists no longer require mechanical models for interpreting physical phenomena. Nevertheless, mechanics is still the foundation of all modern physics in the sense that its generalized principles such as the conservation of momentum, the conservation of mass or energy, and the principle of least action are still basic to physics. Hence physical mechanics needs to be taught in relation to all modern branches of physics and taught necessarily by physicists, who are intimately concerned with the new foundations of physics.

As a mathematical physicist, I would emphasize in such a course the operational point of view with respect to the world of physical phenomena, the physical use of mathematics with respect to the world of mathematical concepts, the scope and limitation of mechanistic philosophy with respect to the world of physical theory. In the tradition of natural philosophy the subject should be treated both experimentally and philosophically. From this point of view, therefore, analytical mechanics and applied mechanics, worthwhile in their own domains, could certainly not be identified with physical mechanics.

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U. S. Office of Education
and ASEE representative on the Advisory Committee of FSAF

The Future Scientists of America Foundation (FSAF) was born four years ago out of the conviction on the part of a group of educational leaders that the best way to improve the long-range supply of engineers, scientists, and technicians is to increase the numbers of qualified boys and girls coming out of high school with adequate preparation for good college or technical institute work in these fields and interested in careers in one of these fields. The Foundation was formed only after extensive consultation with scientists and educators, and was organized as an activity of the National Science Teachers Association (NSTA). It operates under an Administrative Committee including representatives of the sciences, engineering, and education, and with the advice and counsel of an Advisory Committee representing industries and societies interested in the objectives of the Foundation.

Within six months after its establishment, enough money had been contributed by industries and the professional societies to add two full-time people to the NSTA staff and to launch the Foundation's program. An extensive survey was conducted among teachers, professional societies, and industrial organizations to determine current practices, problems, and gaps in the materials and services available for encouraging young people toward engineering, scientific, and technical careers. The results of this survey, published in 1953, identified the objectives and suggested procedures for the Foundation.

The Foundation seeks to secure for junior and senior high school science students and their teachers services comparable to those existing at college and post-graduate levels. The Foundation does not attempt to replace any agencies now active in the promotion of science and engineering, but rather to supplement and coordinate efforts so that there can be continuous assistance available from the elementary through the secondary school and the college up to and including post-graduate levels.

With this in mind, close relationships have been established with the Engineering Manpower Commission, the Scientific Manpower Commission, the Manufacturing Chemists Association, the National Science Foundation, the American Society for Engineering Education, and other organizations, and will be extended to other groups interested in the purposes of the Foundation.

The basic purposes of the Foundation are (1) to help *all* high school youth understand the fundamental principles of science, engineering, and technology, and (2) to help *able* high school youth to become interested in

and to prepare for careers in these fields and in science teaching.

The financial support given to the Foundation by industries and societies has increased very satisfactorily, from an initial budget of $3,000 in 1952 to actual contributions of about $47,000 during 1955. A much wider participation of industry will be sought for next year so that the Foundation can proceed with the expanded program recommended by the Advisory Committee.

The activities of the Foundation can perhaps best be described by a brief account of a meeting last fall of the Administrative Committee with the Advisory Committee, in which accomplishments for 1955 were reviewed and plans for 1956 were formulated.

1. *Science Achievement Awards for Students*

In this program, sponsored for the fourth year by the American Society for Metals, awards and honorable mentions were given to more than 450 students in 186 high schools in 41 states. The program will be continued into 1956 and, if possible, expanded.

2. *Summer Conferences for Teachers*

These conferences have been given financial support by the Crown-Zellerbach Foundation. The first, in 1954, dealt with the identification of laboratory skills which are a hazard to science students. The second, in 1955, dealt with the mathematical hurdles to success in high school science teaching. The teachers in these conferences are used as a research team, and the results of their studies are published and made available to other teachers. This program will be continued and, if possible, expanded in other parts of the country for 1956.

3. *Bibliography of Career Information and Guidance Material*

The third edition of this bibliography was published in 1955. This service, which the Advisory Committee considered of much value, will be continued and, if possible, expanded in 1956.

4. *Science-related Summer Jobs*

This program will be continued for its third year in 1956, with FSAF playing a catalytic role and not attempting to set up a central clearing house.

5. *Science Teachers Research Assistantships*

During the summer of 1955, about 45 science teachers were placed as research assistants on 18 campuses. Their experiences will be publicized in an Evaluation Report now being prepared. This service will also be continued in 1956.

6. *"If You Want to Do a Science Project"*

A booklet with this title was developed to help students get started on science projects. The Advisory Committee considered it valuable to both teachers and students.

7. *"Tomorrow's Scientists"*

A new eight-page monthly publication will be tested in the spring of 1956. It will contain stories of the work of today's scientists and what that work means for tomorrow, announcements of scholarships, student work reports, and similar items of interest.

8. *"Careers in Science Teaching"*

This booklet portrays science teaching, and is published as an effort to interest more students in preparing for this much needed profession. It has been widely circulated among students, and it is planned to distribute at least 10,000 copies during 1956.

(Copies of the publication "Facts About the FSAF" are available from the Foundation, National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington 6, D. C.)

NUCLEAR RESEARCH PROJECTS IN MECHANICAL ENGINEERING

1. Effect of wetting on boiling heat transfer.
2. Effect of acoustic vibrations on convective heat transfer.
3. Heat transfer in thermal-entrance regions.
4. Nuclear energy in relation to the oil industry.
5. High flux heat transfer to boiling water.
6. Heat transfer up to high boiling rates from wire configuration to sub-cooled and saturated water.
7. Investigation of changes resulting from radiation damage to materials.

The above topics have been submitted by Herbert S. Isbin, Associate Professor of chemical engineering, the University of Minnesota, as a supplement to his article, "Survey of Nuclear Engineering Research," which appeared in the September, 1955, JOURNAL.

DR. ALBERT H. COOPER

Dr. Albert H. Cooper, a member of the ASEE since 1936 and Editor of the Chemical Engineering Division, has joined America Hard Rubber Company as an assistant to W. M. Bergin, Director of Research and Development. A well-known authority on organic and inorganic chemicals. Dr. Cooper will devote a major part of his time to chemical research and allied production programs. He will continue as Head of the Chemical Engineering Department at Pratt Institute, Brooklyn.

GUIDANCE MATERIALS FOR MATHEMATICS

A Selected Bibliography

This list is published at the request of the Secondary Schools Committee of ECAC. Thanks are due Dr. Eugene Nichols, formerly of the University of Illinois Committee on School Mathematics Experimental Project, for making available the publications concerned. (The order of presentation is alphabetical, not evaluative.)

1) *Careers for Mathematicians.* Monograph No. 5, Career Publications, 14 West 45th Street, New York 36. *Price* $1.00. (Leading national employers describe mathematical positions open to young graduates.)
2) *Catalogue of General Electric Publications for Schools.* (8 pp. All GE publications listed are free on request to Department 2-119, The General Electric Company, Schenectady 5, New York).
3) *GE's Answer to Three Why's.* (Why study math, science, engineering; 10 pp.) *GE's Answer to Four Why's.* (Study, work, English, read; 12 pp.) *GE Looks at Engineering Tomorrow.* (Career for the future; 4 pp.)
4) *Math at General Electric.* (Sample problems in various areas; 15 pp. of industry applications.)
5) *Why Study Math?* (What math is, why know it, occupations that use it; 8 pp.)
6) Guidance Pamphlet in Mathematics for High School Students. National Council of Teachers of Mathematics, 1201 Sixteenth Street, N.W., Washington 6, D. C. *Price* 25¢ per copy; 40 pp. (Occupational breakdowns of how much and what kinds of mathematics are needed in various professions, plus geographical list of colleges offering the doctorate in mathematics; selected references.)
7) "Mathematical Preparation for College," by P. D. Edwards, P. S. Jones, and B. E. Meserve. Reprint from *The Mathematics Teacher* (Vol. XLV, May, 1952); available from the National Council. *Price* 25¢ per copy. (Lists occupations requiring *high school* training in mathematics, with a little on college-level occupations; 12 pp. Considered "very good" by high school teachers.)
8) *Math Problems from Industry.* (Chrysler Corporation sample practical puzzlers, illustrated with blueprint drawings; 51 problems.) Free on request to Educational Services, Chrysler Corporation, Post Office Box 1919, Detroit 31, Michigan.
9) *Answers to Math Problems from Industry.* (Teacher's hints on methods and numerical solutions to problem volume.) Chrysler Corporation; free as above.
10) *Why Study Mathematics?* The Canadian Mathematical Congress, Engineering Building, McGill University, Montreal, Canada. 33 pp., *price* 50¢ per copy. (Excellent discussion of mathematical careers in broad terms: those requiring expert knowledge, special fields, and "substantial foundation" study. Also, the

mathematics needed in the education of a competent citizen; the contribution of mathematics to sound reasoning in other fields, and the rewards of mathematical training in intellectual and aesthetic satisfaction! Includes "suggestions for further reading." Considered "very good" by high school teachers.)

GORDON RESEARCH CONFERENCES

The 1956 Gordon Research Conference of the American Association for the Advancement of Science will be held from June 11 to August 31 at three New Hampshire schools: Colby Junior College, New London; New Hampton School, New Hampton; and Kimball Union Academy, Meriden. Established to stimulate research in universities, research foundations, and industrial laboratories, the conferences consist of scheduled lectures and discussion groups. Topics included in the approximately 36 week-long sessions of special interest to ASEE members are Instrumentation, Metals at High Temperatures, Chemistry and Physics of Metals, Statistics in Chemistry and Chemical Engineering, Adhesion, Stream Sanitation, Nuclear Chemistry, Chemistry and Physics of Isotopes, Solid-State Studies in Ceramics, Ion Exchange Factors, High-Pressure Research, Infrared Spectroscopy, and Characteristics of Strength, Fracture, and Surfaces for Glass. While registration has been filled for the series by some 3000 participating scientists, substantially the same programs are presented each year. Inquiries for information about the 1957 schedule may be directed to AAAS, 1515 Massachusetts Avenue, N.W., Washington, D. C.

DISCUSSION OF "RISK ANALYSIS"

An expansion and application of Risk Analysis techniques as presented by F. A. Gitzendanner (JOURNAL, October, 1955, p. 182) has been received and accepted by the author too late for publication in this issue. It is, however, available for use by any readers who may be interested, and will be published as early in the fall as possible.

NEW MEMBERS OF THE ASEE

The following two groups of new members conclude the lists for the year 1955–56. The first includes members as of May 7; the second, those to May 22, 1956.

BACIK, RICHARD JAMES, Staff Administrator in Education, American Society of Tool Engineers, Detroit, Michigan. W. Leighton Collins, K. J. Trigger.

BACKUS, KERBY DEWEL, Instructor in Engineering Drawing, The Rice Institute, Houston, Texas. A. P. McDonald, L. B. Ryon.

BALTER, LESLIE M., Director, Jersey City Technical Institute, Jersey City, New Jersey. D. C. Metz, K. J. Holderman.

BAREITHER, HARLAN DANIEL, Associate Professor in Mechanical Engineering, University of Illinois, Urbana, Illinois. N. A. Parker, S. Konzo.

BECK, BETTY ANNE, Research Engineer, Denver Research Institute, Denver, Colorado. J. A. McGlothlan, A. M. Krill.

BERGDOLT, VOLLMAR E., Assistant, Engineering Experiment Station, Purdue University, West Lafayette, Indiana. J. B. Jones, C. W. Rezek.

BIRKEMEIER, WILLIAM PHILIP, Instructor of Electrical Engineering, Purdue University, Lafayette, Indiana. J. S. Johnson, P. Weinberg.

BLEKKING, EARL HENRY, Interim Instructor in Industrial Engineering, University of Florida, Gainesville, Florida. E. P. Martinson, A. C. Kleinschmidt.

BRUCE, JOHN P., Instructor in Pattern Making, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

BRYAN, WILLIAM L., Associate Professor in Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. E. Laitala, W. E. Nudd.

CARLSON, DALE ARVID, Instructor in Civil Engineering, University of Washington, Seattle, Washington. R. H. Meese, R. H. Bogan.

CARROLL, J. RAYMOND, Associate Professor of Mechanical Engineering, University of Illinois, Urbana, Illinois. W. L. Hull, N. A. Parker.

COOPER, ROBERT MARION, Assistant Professor of Engineering Mechanics, University of Michigan. Ann Arbor, Michigan. T. A. Boyle, W. E. Thomas.

DINKER, JOHN D., Associate Professor of Civil Engineering, University of Pittsburgh, Pittsburgh, Pennsylvania. W. I. Short, A. Ackenheil.

DONNELLY, JAMES BERNELL, Instructor in Mechanical Engineering, Villanova University, Villanova, Pennsylvania. J. S. Morehouse, J. N. Walton.

DUCK, HOWARD BECTON, JR., Instructor in Engineering Drawing, Rice Institute, Houston, Texas. A. P. McDonald, L. B. Ryon.

DUNNING, ERNEST LEON, Associate Professor of Mechanical Engineering, Louisiana Polytechnic Institute, Ruston, Louisiana. J. J. Thigpen, J. G. Chumbley.

DUQUETTE, DOUGLAS DONALD, Lecturer in Engineering Mathematics, Assumption University, Windsor, Ontario. D. C. Hunt, J. Gerardi.

EISENSTADT, RAYMOND, Assistant Professor in Mechanical Engineering, Union College, Schenectady, New York. A. Hoadley, G. Ketchum.

ELNAN, ODIN, Assistant Professor of Aeronautical Engineering, University of Cincinnati, Cincinnati, Ohio. H. K. Justice, D. J. Schleef.

FLECKENSTEIN, EDWARD LOUIS, Head of Electrical Engineering Technology, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

FONTAINE, WILLIAM E., Professor of Mechanical Engineering, Purdue University, Lafayette, Indiana. J. B. Jones, C. W. Rezek.

GUNNING, HENRY C., Dean of the Faculty of Applied Science, University of

British Columbia, Vancouver, British Columbia. W. O. Richmond, A. D. Moore.

HALSTEAD, WILLIAM ROBERT, Head of Electrical and Electronics Departments, Southern Technical Institute, Chamblee, Georgia. L. V. Johnson, M. R. McClure.

HAYS, FRANK D., Assistant Professor of Technical Institute, Purdue University, Lafayette, Indiana. J. C. Rapalski, C. F. Rhodes.

HEAD, GEORGE PECHAM, Instructor of Architectural Engineering, University of Detroit, Detroit, Michigan. L. R. Blakeslee, H. Gudebski.

HUBERT, CHARLES IRVING, Associate Professor in Electrical Engineering, U. S. Merchant Marine Academy, Northport, New York. E. W. Starr, P. Nudd.

KAUFMAN, JOSEPH JERRY, Design Instructor, Academy of Aeronautics, New York, New York. W. M. Hartung, A. N. Behr.

KEEGAN, FRANK J., Director, Keegan School of Television, Memphis, Tennessee. D. C. Metz, W. L. Collins.

KOPP, EDGAR WILLIAM, Assistant Professor in Industrial Engineering, University of Florida, Gainesville, Florida. E. P. Martinson, A. C. Kleinschmidt.

LAUGHLIN, HERMAN GLEYN, Assistant Professor in Mechanical Engineering, Purdue University, Lafayette, Indiana. A. R. Holowenko, C. W. Rezek.

MACFARLANE, CARL SHAW, Director of Admissions, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

MACKEY, ALAN ANDREW, Assistant Professor in Mathematics, Northeastern University, Boston, Massachusetts. F. R. Henderson, W. C. White.

MCKINNEY, ROSS ERWIN, Assistant Professor of Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. W. L. Collins, J. C. Dietz.

NOEL, SIDNEY QUIN, President, Universal Television System, Inc., Kansas City, Missouri. J. I. Miller, T. J. Rung.

NOLAN, WILLIAM MARCUS, Technical Personnel Recruiter, American Viscose Corporation, Philadelphia, Pennsylvania. B. B. Bright, W. F. Houghton.

NOVAK, LOUIS, Instructor in Drafting, Wentworth Institute, Boston, Massachusetts. P. H. Ferzoco, R. A. Wilder.

OWENS, OWEN G., Associate Professor in Electrical Engineering, Union College, Schenectady, New York. H. W. Bibber, C. F. Goodheart.

PATTERSON, RALPH E., JR., Associate Professor in Engineering Extension, Iowa State College, Ames, Iowa. G. R. Henninger, L. O. Stewart.

POLAND, ROBERT LOUIS, Counselor, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

PUGH, DAVID B., Industrial Supervisor, The Ohio Mechanics Institute, Cincinnati Ohio. P. K. Johnston, K. R. Miller.

RAMACHANDRAN, ARCOT, Assistant Professor of Mechanical Engineering, Indian Institute of Science, Bangalore, India. J. B. Jones, C. W. Rezek.

RAMMEL, WILLIAM GREGORY, Instructor in Building Construction, Purdue University, Fort Wayne, Indiana. V. Daugherty, M. D. Adams.

RENZ, ALLEN GEORGE, Instructor in Engineering Drawing, Washington University, St. Louis, Missouri. H. E. Grant, G. Nadler.

RESWICK, JAMES B., Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts. J. E. Arnold, W. M. Rohsenour.

ROGNESS, M. L., Assistant Professor in Engineering Drawing, Iowa State College, Ames, Iowa. C. Foster, C. A. Arnbal.

RUMPS, PAUL PETER, JR., Instructor in Chemical Engineering, University of Detroit, Detroit, Michigan. H. Gudebski, C. G. Duncombe.

SCHMID, MERLE D., Assistant Professor in Industrial Management, Pudue University, Lafayette, Indiana. V. W. Daugherty, W. L. Collins.

SLAVEN, G. C., Instructor in Engineering, West Virginia Institute of Technology, Montgomery, West Virginia. D. H. Pletta, H. W. Speiden.

SOLBERG, ARCHIE NORMAN, Dean of Research and Special Services, University of Toledo, Toledo, Ohio. E. D. Harrison, E. W. Weaver, Jr.

SORENSEN, SVEND ERIK, Instructor in Mechanical Engineering, Ohio University, Athens, Ohio. E. J. Taylor, P. H. Black.

SUTER, ANNA K., Assistant Professor of Mathematics, Purdue University, Lafayette, Indiana. A. W. Collins, W. L. Collins.

SWANSON, ROGER PAUL, Head of Aircraft Department, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

THOMPSON, WARREN H., Instructor in Industrial Electricity, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

THOREN, THEODORE ROOSEVELT, Staff Director in Engineering Research and Development, Thompson Products, Inc., Cleveland, Ohio. E. J. Massard, W. L. Collins.

VERRECCHIA, THOMAS ANTHONY, Instructor in Electronic Department, Wentworth Institute, Boston, Massachusetts. H. R. Beatty, F. H. Linton.

WESTFALL, CLAUDE ZEBEDEE, Instructor in Engineering Graphics, University of Maine, Orono, Maine. E. R. Weidhaas, M. McNeary.

WILSON, RICHARD C., Instructor in Mechanical Engineering, University of Michigan, Ann Arbor, Michigan. T. A. Boyle, W. E. Thomas.

WOJCIESZAK, LEO L., Senior Instructor, Academy of Aeronautics, New York, New York. W. M. Hartung, C. S. Jones.

59 new members

Final list as of May 22, 1956

ALLEN, WYETH, Professor of Industrial Engineering, University of Michigan, Ann Arbor, Michigan. F. L. Schwartz, G. G. Brown.

BAYER, CHARLES HENRY, Consultant to Engineering Services, General Electric Company, Schenectady, New York. M. M. Boring, H. G. Hutton.

BEER, CRAIG EUGENE, Instructor in Agricultural Engineering, Iowa State College, Ames, Iowa. K. K. Barnes, H. Beresford.

BELMAN, B. IRAN, Instructor of Graphics and Engineering, Fresno Junior College, Fresno, California. D. E. Whelan, Jr., H. H. Wheaton.

BERGSTROM, ROBERT EARL, Instructor in Product Engineering, General Motors Institute, Flint, Michigan. H. M. Dent, Earl D. Black.

BRUCE, JAMES D., Assistant Professor of Electrical Engineering, West Virginia Institute of Technology, Montgomery, West Virginia. R. M. Kerchner, E. L. Sitz.

BURCHINAL, JERRY CAMERON, Assistant Professor of Civil Engineering, West Virginia University, Morgantown, West Virginia. M. J. Smith, W. H. Baker.

BYRNE, SYDNER HUMMER, Assistant Dean of Engineering and Architecture, Virginia Polytechnic Institute, Blacksburg, Va. G. A. Barnes, Jr., J. W. Sjogren.

CHANDLER, ALFRED D., JR., Assistant Professor of History, Humanities, Massachusetts Institute of Technology, Cambridge, Mass. M. M. Boring, W. L. Collins.

CHOATE, DAVID C., Chairman of Engineering Graphics, Ohio Mechanics Institute, Cincinnati, Ohio. P. K. Johnston, K. R. Miller.

CLEMENTSON, GERHARDT CHRISTOPHER, Professor of Aerodynamics, U. S. Air Force Academy, Aurora, Colorado. A. Higdon, J. D. Hempstead.

DACCARDO, SAMUEL, Evening Instructor in Technical Drawing, Illinois Institute of Technology, Chicago, Ill. J. T. Dygdon, E. V. Mochel.

ECKBERG, HERBERT FREDERIC, Professor of Mechanical Engineering, Bucknell University, Lewisburg, Pennsylvania. H. D. Sims, W. Garman.

ECKEL, JAMES ROBERT, JR., Instructor in Electrical Engineering, University of Tennessee, Knoxville, Tennessee. W. O. Leffell, J. D. Tillman.

ELKINS, RICHARD LONSDALE, Instructor in Mechanical Engineering, University of Maryland, College Park, Maryland. J. E. Younger, R. W. Hurlbrink, Jr.

FISCHER, RICHARD JEFFERSON, General Personnel Supervisor, N. W. Bell Telephone Co., Des Moines, Iowa. L. O. Stewart, M. S. Coover.

GRIFFITH, EDWIN GEORGE, Instructor in Electrical Engineering, Allentown Extension Center, Pennsylvania State University, University Park, Pennsylvania. V. E. Neilly, H. J. Herbein.

HAMLIN, ROGER B., Instructor in Engineering and Cultural Studies, General Motors Institute, Flint, Michigan. H. O. Haskitt, Jr., M. H. Swift.

HARMS, WILLIAM OTTO, Assisttant Professor of Chemical Engineering, University of Tennessee, Knoxville, Tenn. E. E. Stansbury, H. F. Johnson.

HEARN, EMMETT E., Director of Employment, The Glenn L. Martin Company, Baltimore, Maryland. H. S. Stillwell, J. E. Dahlman.

HENSON, JAMES O., Lecturer in Civil Engineering, University of Tennessee, Knoxville, Tennessee. R. F. Bullock, A. T. Granger.

HERTENSTEIN, HAROLD NELSON, Supervisor, Engineering Training, McDonnell Aircraft Corporation, St. Louis, Missouri. G. E. Dreofke, F. H. Roever.

HOBSON, JAMES WALKER, Assistant to the President—Administrative, Lawrence Institute of Technology, Highland Park, Michigan. M. M. Ryan, E. Lawrence.

HOGAN, RANDALL JAMES, Instructor, Engineering Extension, The Pennsylvania State University, University Park, Pennsylvania. E. M. Elias, T. R. Horn.

HWANG, MING CHAO, Instructor in Mathematics, Academy of Aeronautics, New York, New York. A. Behr, C. H. Coder, Jr.

JAGGARD, ERNEST PLACK, Instructor in Engineering Extension, The Pennsylvania State University, University Park, Pennsylvania. K. L. Holderman, T. A. Wright.

JOHNSON, FRED M., Associate Engineer, Lawrence Adams Co., Modesto, California. D. E. Whelan, Jr., J. E. Sakaly.

LEE, MARY HELEN, Engineering Librarian, Purdue University, Lafayette, Indiana. A. K. Branham, G. A. Leonards.

LIND, TOIVO A., Project Engineer, Tractor Engineering Test & Development, Ford Motor, Tractor & Implement, Dearborn, Michigan. H. E. Hedinger, G. P. Brewington.

LINEBARGER, ROBERT MEAL, Part-time Instructor in Civil Engineering, Brigham Young University, Provo, Utah. D. K. Fuhriman, B. Brown.

MYSINGER, EDWARD DOUGLAS, Instructor in Civil Engineering, University of Tennessee, Knoxville, Tennessee. R. E. Bullock, A. T. Granger.

MCCLELLAND, FRANK MORGAN, Instructor in Electrical Engineering, University of Tennessee, Knoxville, Tennessee. H. M. Scull, W. O. Leffell.

PEASE, DONALD A., Specialist in Engineering Training, General Electric Company, Small Aircraft Engine Department, West Lynn, Massachusetts. J. C. Truman, J. R. Levitt.

PENZIEN, JOSEPH, Assistant Professor of Civil Engineering, University of California, Berkeley, California. E. P. Popov, B. Jameyson.

PERDUE, JOHN VICTOR, Industrial Coordinator, University of Detroit, Detroit, Michigan. S. J. Hirschfield, C. J. Freund.

PUNCOCHAR, ROBERT P., Instructor in Mechanical Engineering, South Dakota State College, Brookings, South Dakota. L. Amidon, K. E. Lindley.

RAU, ARTHUR H., Consultant to Engineering Services, General Electric Company, Schenectady, New York. M. M. Boring, H. G. Hutton.

REAL, RAYMOND V., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebraska. D. N. Pierce, D. I. Cook.

RUBIN, LLEWELLYN ADAM, Assistant Instructor in Electrical Engineering, Moore School of Electrical Engineering, University of Pennsylvania, Drexel Hill, Pennsylvania. Ernest Frank, H. Sohon.

SEARCRIST, GEORGE KENNETH, Instructor in English, the Pennsylvania State University (York Center), University Park, Pennsylvania. E. M. Elias, T. R. Horn.

SESONSKE, ALEXANDER, Associate Professor of Chemical Engineering, Purdue University, Lafayette, Indiana. S. C. Hite, T. J. Hughel.

SMITH, ALBERT P., Instructor in Engineering Extension, The Pennsylvania State University, University Park, Pennsylvania. H. J. Herbein, T. J. Rung.

SMITH, DONALD HUBBELL, Instructor in Engineering, The Pennsylvania State University Center, University Park, Pennsylvania. K. L. Holderman, T. J. Rung.

SNYDER, HARRY R., Coordinator of General and Industrial Education, Arabian American Oil Co., Dhahran, Saudi Arabia. E. E. Booher, K. Zeigler.

SPIES, HENRY RAYMOND, Assistant Editor, Engineering Experiment Station, University of Illinois, Urbana, Illinois. E. C. McClintock, R. J. Martin.

STEWART, WALTER WM., Staff Assistant in R & D Department, American Viscose Corporation, Philadelphia, Pennsylvania. W. F. Houghton, B. B. Bright.

TOMLINSON, MAURICE JOHN, Head of Department of Construction, Provincial Institute of Technology and Art, Calgary, Alberta, Canada. E. W. Wood, W. L. Collins.

WERNER, HAROLD D., Instructor in Engineering Extension, Pennsylvania State University, University Park, Pennsylvania. K. L. Holderman, T. J. Rung.

ZIMMERMAN, JOHN R., Instructor in Engineering Extension, Pennsylvania State University, University Park, Pennsylvania. H. Herbein, K. L. Holderman.

59 new members as of May 7
49 new members—final list
531 previously added

639 total new members 1955–56

MELVIN L. ENGER

Dean Emeritus Melvin L. Enger died May 13, 1956, in Escondido, California, where he has lived since retiring seven years ago from the position of Dean of Engineering at the University of Illinois, Urbana. Professor Enger, who served on the Illinois engineering faculty for 42 years, also became director of the Engineering Experiment Station in 1934, when he was appointed Dean. A member of the ASEE since 1907, Dean Enger was a member of the General Council from 1921 to 1924, and Vice President from 1938–39.

TEACHING POSITIONS AVAILABLE

ELECTRICAL, MECHANICAL, CHEMical Engineering, and also Mathematics and Physics staff openings. Industrial experience desirable. Opportunity for research. Franklin Technical Institute, 41 Berkeley Street, Boston 16, Massachusetts.

ASSISTANT PROFESSOR OR INSTRUCtor to teach fundamental heat power and related fields. Compensation dependent on qualifications. Long established college, high professional reputation. Graduate Study opportunities available. Location, New York City. Appointment to start September, 1956. Send resumé. JUN-1.

ASSOCIATE PROFESSOR, ASSISTANT Professor, or Instructor, (rank and salary determined by training and experience) to teach courses in the Petroleum Production Option. Teaching period nine months. Opening, September 1, 1956. Location, Southwest. JUN-2.

ASSOCIATE, ASSISTANT, PROFESSOR or Instructor, rank dependent upon training and experience, to teach basic mechanical engineering courses. Machine design experience preferred. M.S. degree or teaching experience desirable. Position available September 1, 1956. Write to Head, Department of Mechanical Engineering, South Dakota State College, State College Station, Brookings, S. D.

ELECTRICAL ENGINEERING INstructors and Professorial rank teachers needed for the 1956–57 academic year. Extensive graduate program and research activities. Write to Head, Electrical Engineering Department, The Pennsylvania State University, University Park, Pennsylvania.

RESEARCH ASSISTANTSHIP IN LUBRIcation. Graduate study and paid part-time work with experienced staff in hydrodynamic lubrication of bearings. Start September or February. Write to Professor George DuBois, Department of Machine Design, Cornell University, Ithaca, New York.

CIVIL ENGINEERING INSTRUCTOR and Assistant Professor needed. Assistant Professor to take charge of surveying, highway course sequence, and surveying camp. Eastern metropolitan college, start September 1, 1956. JUN-3.

ELECTRICAL ENGINEERING POSITION to teach undergraduate courses. M.S. required. Opportunity for graduate study, industrial consulting, or research. Rank and salary open. Start September 1956. University of Santa Clara, Santa Clara, California.

ASSISTANT PROFESSOR AND INSTRUCtor at growing midwest engineering college in Department of Mechanical Engineering, effective fall semester 1956–57. Assistant Professor must have special experience or training in machine design. Teaching assignment for instructor would include: Heat-Power, Manufacturing Processes, and Laboratory. Salary in both grades dependent upon qualifications. JUN-4

EJC Report on Professional Standards and Employment Conditions

Editorial Note: If engineering is to be accepted fully as a profession in the strict sense, engineers, their employers, and colleges of engineering all have responsibilities. What are they? The Committee on Employment Conditions of Engineers Joint Council studied the problem, prepared a report, had it reviewed by a special Task Committee, reviewed again by the EJC Executive Committee, and finally approved by the EJC Board of Directors at its meeting on March 16, 1956.

As an authoritative statement of the problem, the report is printed here in its entirety for the benefit of ASEE members; other constituent societies are giving it similar circulation. In addition, EJC is printing a limited number of separate copies. Some are being sent to each dean of engineering, and others are being made available without charge to those interested. Requests should be sent to E. Paul Lange, Secretary, Engineers Joint Council, 29 West 39th Street, New York 18.

FOREWORD

Unlike the members of most learned professions, the engineer usually is an employee rather than a private practitioner. Surveys indicate that about eighty per cent of professional engineers are in the employee classification, and this situation sometimes creates special problems which are not inherent in the other professions. One such problem is how specifically to create and maintain an employment atmosphere consistent with high professional standards.

Certain conditions of employment have had a profound influence on engineers and, among other factors, have caused a number of professional employee groups to turn to collective bargaining. There is a need, therefore, for the engineering profession to state clearly the employment conditions that engineers expect as professional men. Employers should align their policies with respect to the engagement of professional engineering personnel to meet these expectations. Mutual understanding between employers of engineers and the engineering profession is essential to the establishment of an environment which will encourage the individual engineer to achieve full professional stature.

A special committee of Engineers Joint Council was charged with a study of this employment problem and the preparation for Engineers Joint Council of "a means of education of and vertical communication to the membership of the constituent societies (including students) concerning conditions surrounding unionization of professional personnel."

Another assignment of the special committee was the preparation of information for employers of engineers concerning employment practices, educational opportunities, and general measures for pro-

fessional development that influence the attitudes of engineers toward a true professional outlook.

This study treats but one of many problems confronting the profession. Engineers Joint Council will continue its study of the problems related to the employed engineer.

ENGINEERS JOINT COUNCIL REPORT ON PROFESSIONAL STANDARDS AND EMPLOYMENT CONDITIONS

The Board of Directors of Engineers Joint Council has adopted the following report, which comprises an analysis of problems of current employment conditions as they relate to the individual engineer. The major topics studied and covered in this report are as follows:

1. The Present Situation
2. The Causes of This Condition
3. Summary of Historical Background
4. Statement of the Problem and Suggested Solutions
5. Engineering—a Profession
6. Employee's Responsibilities in the Engineering Profession
7. Management's Responsibilities in the Engineering Profession
8. Engineering Societies' Responsibilities in the Engineering Profession
9. Engineering Education's Responsibilities in the Engineering Profession
10. Conclusions and Recommendations

1. The Present Situation

The expansion of engineering from its beginning in military and civil engineering a century ago to a multiplicity of disciplines today has created a host of problems. Of major concern to the engineer is his relationship as a professional man with his employer. This relationship is influenced largely by employment conditions, including salaries, training programs, security policies, levels of responsibility, job classifications, and identification with management.

Because the needs, responsibilities, and contributions of professional employees have not been recognized adequately in some instances, there has been a movement toward the unionization of engineering personnel. This has had an adverse affect on the professional concepts of many engineers, for a professional man must rely primarily on his own personal competence and integrity for recognition. In addition, confidential relationships which should exist between employers and professional engineers have been jeopardized.

The fact that there has been a trend toward collective bargaining by engineers, in spite of widespread reluctance to participate in such action, indicates the existence of unsatisfactory conditions. The engineering profession and management have a great stake in the solution of the problem and the latter must accept its share of

the responsibility for alleviating unfavorable employment conditions.

2. The Causes of this Condition

Reasons which have fostered collective bargaining among engineers have been studied and may be grouped as follows:

A. *Professional Treatment*

a. A feeling among engineers that they were not identified with management, whether they were employees in industry, in private engineering firms, or in the public service.
b. Inadequate channels of communication between top management and nonsupervisory engineers.
c. Inadequate recognition of the engineer as a professional employee.
d. Assignment of engineers to subprofessional work.
e. Undue retention of engineers in specialized and narrowly compartmentalized assignments.
f. Lack of appropriate means for resolving individual problems.

B. *Personal Treatment*

a. Inadequate recognition and treatment of the engineer as an individual.
b. Lack of broad position classifications and appropriate titles by which the engineer could measure his progress.
c. Inadequate or nonexistent plans for training and job rotation.
d. Inadequate understanding of promotional policies and belief that progress and promotions were not commensurate with ability and performance.
e. Feeling of insecurity of employment.
f. Management's human relations knowledge and skills have not kept pace with the expanded utilization of engineers.

C. *Financial Treatment*

a. Engineering salaries not commensurate with fundamental contribution.
b. Too small a differential between the pay of engineers and members of the skilled trades.
c. Salaries of experienced engineers not sufficiently increased, in comparison with present starting salaries.
d. Wide variation in salaries paid to engineers doing comparable work in different organizations.
e. Dissatisfaction with merit review systems and inadequate understanding of salary administration.

Faced with these conditions, some engineers have resorted to unionization in the belief that corrective action could be effected only by pressures on management through collective bargaining. Even though they may have realized that professionalism requires freedom of action, these engineers appear to have been willing to submerge this principle in their attempt to get more pay and better working conditions through union activity.

3. Summary of Historical Background

The accelerated development of mass-production techniques in this century stimulated a rapid rise in labor union activities. Labor and management faced common problems of increasing complexity. In 1935 the United States Congress enacted the National Labor Relations Act, better

known as the Wagner Act, which guaranteed to employees the right to organize and to bargain collectively, and protected labor unions against specified unfair labor practices on the part of management. At that time there was little realization on the part of the professions of the potential impact of the Wagner Act on professional employees. However, the established labor unions soon took advantage of the situation, and it was not long until many professional employees found themselves included, against their individual desires, in heterogeneous bargaining groups.

Legally, it was possible to form bargaining groups composed solely of professional employees. Practically, it was difficult to do so. Wherever a heterogeneous bargaining unit existed, it was next to impossible for professional employees to segregate themselves since the Wagner Act made no distinction between them and nonprofessional workers.

Some engineering societies, particularly the American Society of Civil Engineers, undertook to chart a course of action designed to assist professional employees against inclusion in heterogeneous groups. At first, the effort met with but minor success. Later, Engineers Joint Council determined to present its views to Congress, with the hope that the Wagner Act might be amended to provide recognition of the status of professional employees and to enable them to act effectively on their own behalf. Pertinent clauses are included in the Labor-Management Act enacted by the Congress in 1947—better known as the Taft-Hartley Act.

Of interest to the engineering profession, this law specifically provides under Section 9 (b):

"The Board shall decide in each case whether, in order to assure to employees the fullest freedom in exercising the rights guaranteed by this ACT, the unit appropriate for the purposes of collective bargaining shall be the employer unit, craft unit, plant unit, or subdivision thereof; PROVIDED that the Board shall not (1) decide that any unit is appropriate for such purposes if such unit includes both professional employees and employees who are not professional employees unless a majority of such professional employees vote for inclusion in such unit. . . ."

The term *professional employee* as included in the Act reads:

"(a) any employee engaged in work (i) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical, or physical work; (ii) involving the consistent exercise of discretion and judgment in its performance; (iii) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (iv) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning or a hospital, as distinguished from a general academic education or from an apprenticeship or from training in the performance of routine mental, manual, or physical processes; or, (b) any employee who has (i) completed the courses of specialized intellectual instruction and study described in clause (iv) of paragraph (a), and (ii) is performing related work under the supervision of a professional person to qualify himself to become a professional employee as defined in paragraph (a)."

Under the Taft-Hartley Act, a group of professional employees in any place of employment may decide by majority vote of their own numbers whether they want to form a unit

of their own for collective bargaining purposes, to join with some other bargaining group, or to refrain from collective bargaining entirely.

It was hoped that the amended act would provide a satisfactory solution to the inclusion of engineers in heterogeneous unions. Professional employees could disassociate themselves from heterogeneous groups. It was not expected that employees of professional status ever would desire anything like a nation-wide bargaining union. It was hoped that labor unions would respect the statutory rights of professional employees. Those hopes today lack much of full realization.

A number of bargaining groups of professional employees have come into existence. Some appear to have functioned constructively; the same hardly can be said of others. Already there is a nation-wide union, self-designated as an engineering union, which aspires to power. Although some professional employees have been able to disassociate themselves from heterogeneous groups, craft unions, particularly in the construction industry, are forcing more and more engineers into their ranks by bringing economic pressure upon employees, thus avoiding the election machinery of the Taft-Hartley Act. Clearly, many members of the engineering profession and employers of engineers are not doing enough to ensure enforcement of the letter and the spirit of the law.

The recent merging of the American Federation of Labor (AFL) and the Congress of Industrial Organizations (CIO) brings into being a large and powerful labor organization among whose objectives are increased efforts toward unionization of office employees and technical personnel. That effort will have direct impact on professional engineers.

To obtain reliable statistics regarding the current status and thinking of a cross-section of the engineering profession, four constituent members of EJC, namely ASCE, ASME, AIEE, and SNAME, polled 117,917 of their members on specific questions concerning collective bargaining. Of those polled 66,938 or 57% responded. Returns showed that 48,082, or 72%, of the 66,938 respondents *opposed* collective bargaining for professional engineers; and that 44,168, or 66%, felt that collective bargaining is *incompatible* with professional status.

Further, the 66,938 responses showed that less than 4% were actually members of established collective bargaining groups; 27% reported as not being opposed to collective bargaining; 20% reported that they believed collective bargaining would be advantageous to them; and finally, less than 1% of the membership of three member societies (the fourth did not ask the question), would prefer to be represented by a craft labor union.

These results present a challenge to the engineering profession and to engineering management. The thinking of the remaining 43% of the 117,917 members polled, who did not respond to the questionnaire, is still unknown, but, assuming that the sample was representative, there would then be 30,300 members who are not opposed to collective bargaining for professional engineers.

These results emphasize the situation confronting the profession in spite of the protective clauses in the Taft-Hartley Act.

4. Statement of the Problem and Suggested Solutions

A summary of the above might lead to two basic reasons for the present situation:

1. Engineers have not always realized and understood the professional characteristics of their roles.

2. Management has not always realized and accepted its obligations to engineers.

If these are the causes, the problem then may be stated as how to get the engineer to appreciate the professional characteristics of his position and how to get management to realize and accept its obligations to its engineers.

Immediately certain solutions present themselves, and these may be listed under five main headings:

1. Point out to the engineer and reemphasize to him that engineering is a profession and that he therefore has certain definite responsibilities.

2. Point out to management, through all feasible ways, that it has responsibilities to the engineering profession.

3. Point out to professional societies the part which they should play in the advancement of their profession.

4. Point out to engineering educators their responsibilities for developing professional concepts in their students.

5. Point out to society the contribution of the engineer to its general welfare.

The purpose of the rest of this report will be to bring to the attention of all concerned their respective responsibilities. It is hoped that sufficient distribution and publicity will be given to it to stimulate a realization on the part of the public that engineering is a profession with high ideals and one that has made preeminent contributions to our modern civilization and high standard of living.

5. Engineering—a Profession

Engineering is the art and science by which the properties of matter and energy are made useful to man in structures, machines, and products. Accomplishment of these ends requires not only scientific training, but also creative imagination, judgment, and an appreciation of the economics involved. The work of the engineer is predominantly intellectual and varied. The dictionary defines engineering as a mental activity rather than a manual skill. The engineer must exercise discretion and judgment, he must wish to serve, and his relationship with management must be one of confidence; in fact he is part of management. The engineer is charged with the protection of the public health and the public safety. The builder of a bridge, an airplane, a water supply system, a dynamo, a kitchen range, an automobile, or a chemical plant must be concerned with its safe operation. Responsibility rests upon his shoulders; if he does not accept that responsibility, he is not professional.

Professions require knowledge and skills on a high plane, and all require that the practitioner work in a relation of confidence. In the ministry, medicine, and law, this relationship is usually on an intimate personal basis, but in engineering it usually is more general and, indeed, involves obligation to the public at large as well as to the employer or client. The engineer's code of ethics requires that "he will have due regard for the safety of life and health of the public and employees who may be affected by the work for which he is responsible" and

that "he will act in professional matters for each client or employer as a faithful agent or trustee."

Since clients and employers usually do not have the technical knowledge necessary to judge technical work, the engineer is bound to place their protection above his personal convenience or his immediate personal gain. A fundamental principle of professional responsibility is trusteeship. This is also a fundamental principle of management. To the employed engineer this means that the professional attitude involves a "management-oriented" point of view.

Engineering operations today are varied and extensive. Men at all levels of training and competence are required to carry out vast engineering enterprises. The work of the draftsman, the layout man, the toolmaker, the plant operator is indispensable, but does not require the imagination, the educational background, or the judgment of the engineer, who conceives and executes the broader aspects of the projects.

The work of a truly professional engineer is so far from a routine, established pattern that only he can provide the initiative, the discretion, and judgment to achieve the successful accomplishment of his particular tasks. Because he alone knows with what comprehension, ability, and likelihood of success he approaches his assignment, the professional must accept individual responsibility or else advise his client or employer that other help is needed.

Professional attitude involves the following five basic concepts:

(1) A social consciousness, a desire to contribute *to* rather than simply to benefit *from* civilization; a resolve to place the public welfare above other considerations.

(2) The acquisition of special skills on a high intellectual plane, generally evaluated by means of self-imposed standards of excellence.

(3) A sense of trusteeship—personal responsibility to protect the client's or employer's interest.

(4) Individual initiative and acceptance of individual responsibility, both of the highest order.

(5) A right to expect and to receive adequate financial recognition.

Prestige, however, is something that must be won. It cannot be bought or automatically accorded through affiliation with an organization. It is something that one can *command* but never *demand*. In the final analysis, an engineer achieves professional standing only to the extent that he accepts his responsibility to himself, to his client or employer, and to society.

Attainment of a degree in engineering from an institution of recognized standing implies that the graduate has mastered a certain curriculum and that he has the ability to understand, to assimilate, and to apply the knowledge that qualifies him to become a member of the engineering profession.

Although social consciousness is not necessarily a corollary to superior mental competence, most people who are endowed with such competence do have a sense of responsibility to the social order of which they are a part. They have learned to look on life as an opportunity to contribute to the civilization that fostered them and thus to better the lot of those who follow. To the engineer who feels that life provides opportunity for constructive contribution to society, collective bargaining with its attendant poten-

tiality for creating conflicting obligations is not acceptable.

6. Employee's Responsibilities in the Engineering Profession

"As an engineer, I will participate in none but honest enterprise. To him that has engaged my services, as employer or client, I will give the utmost of performance and fidelity." (Faith of the Engineer.)

The engineering employee is bound by the same ethical and moral principles that apply to a member of any other learned profession. The responsibilities of an engineering employee are many. He is obliged to perform the professional assignments entrusted to him to the best of his knowledge and ability. He should give needed professional counsel in his special field and render loyal service. He should respect the economic problems of his employer. He should be thorough, expeditious, original, and accurate in the execution of his duties and assignments. He should have a rational attitude toward his work and fulfill each task with a minimum of supervision. At all times he should strive to improve the quality and increase the quantity of his output.

Education is important to the engineer and he should foster its continuance for those who are subordinate to him. He should strive to recognize and to utilize the diverse capacities of all fellow employees. He should strive for good planning and clear, concise reports. He should be friendly and maintain good appearance. He should develop the ability to be a good listener as well as the ability to express his thoughts effectively.

It is axiomatic that just as management has responsibility to employees, so do employees have responsibilities to management. The engineer employee should realize that he is not just another hired hand. He should know that to achieve full professional stature he must develop himself to rise above the technician or engineering assistant. He must have genuine desire to expand his capacity, to extend his knowledge, and to improve his proficiency.

Any employee who is unwilling to assume responsibilities beyond those accompanying his present job has little right to be critical about lack of advancement. If he feels that he is not getting earned recognition, it well may be that critical self-appraisal is in order. One cannot just wish himself up the ladder or depend on someone else to push or pull him along the way to success. The fact that a man has acquired a bachelor's degree in engineering does not, of itself, entitle him to any lasting professional recognition. It remains for each individual to prove by his own ability, integrity and conscientious application to duty that he deserves recognition.

7. Management's Responsibilities in the Engineering Profession

Surveys show that more than forty per cent of management were trained as engineers. It seems illogical, therefore, that often there is inadequate communication between management and engineers, with consequent lack of understanding on the part of management of the reasons for dissatisfaction among professional employees.

Management must recognize the inherent professional character of engineering work. It should be a policy of management to use its professional employees to the maximum of their capabilities. Except during the training period, the engineer should not be assigned to tasks which do not require

his technical training and he should be accorded individual and professional status commensurate with the quality of his contribution.

There must be opportunity for a continuation of education. It is important that professional employees be given opportunities to participate in activities of scientific and technical societies. It is important that they receive credit for their contributions to the advancement of technical knowledge or the profession as a whole.

There must be adequate communication between management and the professional employee. There should be organized orientation and training programs for new employees. Engineers need to understand the basic policies of their employer. They need to know their responsibilities and their opportunities for advancement. Adequate management-employee communications require a day-to-day relationship supplemented by periodic performance reviews, and other appropriate techniques.

Salaries must be established which will recognize the contribution of the professional employees as related to that of other groups. Salary differentials between various levels of technical experience have been substantially narrowed during recent years. Engineers who, after a period of satisfactory employment, find their salaries are only slightly higher than those of the recent graduate and possibly lower than those of a skilled craftsman are not working in a favorable atmosphere.

Management must minimize the fear of job insecurity by adopting feasible means for stabilizing the employment of professional personnel and developing suitable termination policies. Since many engineers become managers, there is a need to insure that they are employed and developed in an atmosphere which will fit them for their future responsibilities. Executive talents must be developed by experience and training in those phases which lead to managerial responsibilities.

8. Engineering Societies' Responsibilities in the Engineering Profession

The engineering societies must take the lead in the advancement of the profession. Among the basic responsibilities of the engineering societies are the establishment of standards of ethical conduct, rigid requirements for admission to membership, accreditation of educational institutions which grant engineering degrees, and awards and prizes in recognition of worthy contributions to the advancement of the profession.

The national engineering societies have an additional responsibility to foster a healthy professional climate for employed engineers. Their governing boards and their individual members should unite in exerting their best efforts towards solving the problem. These responsibilities are so challenging and so vital to the current problem that they must be considered as obligations.

Current efforts of national committees to encourage professional development of engineering society members and to promote recognition by the public of the professional character of the engineers' work should be expanded. An objective evaluation of the problem should be continued, followed by specific recommendations for the good of the profession. Engineering societies should adopt official statements for membership information with respect to collective bargaining

to the extent permitted by their chapters and constitutions. They should acquaint their memberships with those provisions of the Taft-Hartley Act which have a special significance to professional engineers. Constructive programs for encouraging professional consciousness on the part of engineers both before and after graduation should be sponsored. Therefore, the engineering societies and Engineers Joint Council should inform management as to the standards that will contribute to full professional achievement.

The engineering societies should provide guidance and assistance to educational institutions confronted with any problem which is detrimental to the achievement of full professional training of students.

9. Engineering Educator's Responsibilities in the Engineering Profession

Engineering colleges have a primary responsibility for developing professional concepts in engineering students. Professional concepts should be developed through their application to the solution of engineering problems in the technical courses, by lectures, association with students, and by good example.

Opportunities for engineering educators to become better acquainted with the total environment in which engineers work should be expanded through temporary employment in nonacademic fields and the utilization of employers with "professional vision" in the classrooms and student seminars. Such activities enable students to appraise their status more realistically upon graduation.

10. Conclusions and Recommendations

There are obligations and responsibilities resting on both employer and employee. Each, of course, has responsibility to advance his own welfare. Beyond that, and yet a part of it, each has responsibility to the other and to society. Grave responsibilities for inculcating and developing professional consciousness in young members of the profession rest upon the educational institutions and professional societies. Various phases of such responsibilities have been stressed in the several sections of this report.

Without a sound technical foundation no man can become a competent engineer. But more than technical competence is demanded of one who expects to be recognized as a professional person. One must understand and observe appropriate ethical standards and it is important to cultivate proper understanding of such standards.

The ECPD program "The First Five Years of Professional Development" is an excellent step in the right direction. Here is opportunity for the engineering societies, the colleges, industrial management, and civic institutions to work together to aid young graduates in continuing their education and in adjusting themselves to conditions to be met in the practice of their profession.

The present report has been prepared with full realization that the subject refers chiefly to one phase of professional life. An attempt has been made to identify factors that have significant bearing on the specific problem under consideration. Concerted efforts by all concerned with advancement of the profession are required if satisfactory solutions are to be found. It is believed that if the recommendations submitted are followed by those to whom they are directed, substantial improvement in the

standing of the profession will result. There is no simple solution, but EJC recommends that:

1. Management utilize the services of engineers more effectively and thereby afford them opportunity for advancement and economic improvement.

2. Management recognize its responsibility to make engineers feel that they are a part of management.

3. Management survey areas of communication, recognition, and salaries and, where found wanting, correct to conform with standards of professional practice.

4. The engineer take inventory of his services and his actions to make sure that he has a professional attitude toward his work.

5. Engineering societies establish and employ appropriate means to maintain high standards of ethical conduct for professional achievement.

6. Engineering societies encourage the professional development of their members and promote proper recognition of the profession.

7. Engineering educators emphasize the characteristics of the profession.

SUBJECT INDEX

AIP Report on Role of Physics ..M, 512
Annual Meeting, 63rd, J. I. Mattill S, 14
Another Look at General Studies, Weller Embler .....M, 551
Art of Writing, J. H. Bolton .....O, 171
ASEE Directory Changes .....My, 797
ASEE Proceedings Volume .....Ja, 440
ASEE Summer Schools .....Ja, 502
ASEE Summer Schools .....A, 616
ASEE 1956 Yearbook and Directory .....F, 1–320
Award to Garrelts .....Ja, 476

Birth of a Research Project, H. A. M. Flanakin .....D, 358
Blurred Borders of Physics and Engineering, J. H. Van Vleck ..D, 366
Busman's Holiday, Harold A. Foecke M, 573

Can 500,000 Engineers be Professional? Eric A. Walker .....Ja, 421
Candid Comments, J. E. Dean ....S, 99
N, 286
R. H. Upson .....D, 401
M. Levine .....D, 402
"Case Studies" in Materials Laboratory, P. F. Brandenburg ....M, 563
Chicago Industry-Education Conference on Evaluation Report .My, 818
Civil Engineering Division—A. G. C. .....Je, 837
College Notes ....S, 75, 80, 93; O, 126, 131, 139, 159, 162, 170, N, 221, 250; D, 348, 352, 357; Ja, 477
Cooper, Dr. Albert H. .....Je, 857
Colorado A&M Center, New ..My, 794
Communication Problems in the Engineering Science Curriculum, W. E. Wilson .....D, 374
Construction Education Summer School .....M, 578
Cooper Made Chairman .....Ja, 474
Co-op. Educ. 50th Anniversary ..A, 617
Co-op Educ. Resolution ....A, 617
Cooperative Engineering Calendars, D. C. Hunt .....O, 168
Coordination of Architecture, Engineering, and Construction by the Project Method, J. F. Poulton .....D, 383
Corps of Engineers Student Program, Edward J. Rising ... .My, 771

Corrosion Instruction in Engineering Colleges, F. E. Allen ....N, 267
Cracking the Creative Nut, D. S. Pearson .....O, 121
Cronvich, James A., Dean .....My, 801

Designing the Educational Program, G. A. Hawkins .....N, 241
Discussion of "Risk Analysis" ...Je, 860
Do You Know ....S, 6; O, 107; N, 211; D, 309, Ja, 414; M, 528; A, 608; My, 752; Je, 824
Drawing and Graphic Science Summer School .....M, 570

Economics in Chemical Engineering, R. S. Aries and R. M. Cziner ..Ja, 446
Editorial—A Year of Decision ...S, 4
Editorial Policy .....Ja, 469
Educational Requirements for Technical Editors, Kalsem, P. J. ..Je, 832
Education by Research Training, J. T. Rettaliata .....D, 327
Education for Research in Industry, C. G. Kirkbride .....N, 216
Electron Microscope Course ....M, 550
ECPD Accreditation—Additional Criteria .....My, 816
ECPD Accreditation—Introduction, Harold L. Hazen .....My, 814
ECPD—Proposal for Survey of Profession, Thorndike Saville ....Ja, 500
ECPD—Resolution; Origins of Proposal, W. L. McCabe .....Ja, 501
ECPD—Toronto Address: Need for Appraisal, S. C. Hollister ....Ja, 503
EJC Proceedings .....Je, 835
EJC Report, Professional Standards .....Je, 866
Engineering Directory .....My, 789
Engineering Economy Committee Functions, Arthur Lesser, Jr. ..Ja, 498
Engineering Education in Brazil, E. W. Kimbark .....D, 353
Engineering Enrollments and Degrees, 1955, W. A. Jaracz, H. H. Armsby .....F, 509
Engineering Mechanics Survey, G. Wallace Smith .....M, 536
Engineering Research at Iowa State College .....My, 755
ECRC Research Review .....Ja, 457

ENGLISH PROGRAM AS ENGINEERING TEACHERS VIEW IT, Frank Kerekes Ja, 427
ENROLLMENT AND INCOMES IN CIVIL ENGINEERING CAN BE INCREASED, H. Rubey ..... N, 236
EVALUATION OF ENGINEERING EDUCATION, J. K. Wolfe ..... D, 342
EXECUTIVE BOARD MINUTES ..N, 290; Ja, 484; My, 807
EXTRA-CURRICULAR ACTIVITIES, Joseph F. Zimmerman ..... My, 787

FIELD RESEARCH IN CIVIL ENGINEERING, Ardis White ..... My, 768
FIGHT FOR ETHICS IN ENGINEERING, J. R. Snell ..... N, 230
FOR WHAT TYPES OF CAREERS SHOULD WE TRAIN MATHEMATICIANS, R. S. Burington ..... O, 115
FUTURE SCIENTISTS OF AMERICA FOUNDATION, Armsby, H. H. ..... Je, 855

GENERAL EDUCATION IN ENGINEERING COMMITTEE REPORT FOR THE HUMANISTIC-SOCIAL RESEARCH PROJECT ..... A, 619
GENERAL STUDIES FOR ENGINEERS, J. H. Davis ..... O, 109
GENERAL COUNCIL MINUTES ..N, 294; Ja, 485
GEORGE WESTINGHOUSE AWARD, R. R. White ..... S, 97
GORDON RESEARCH CONFERENCES .Je, 859
GRAPHIC SCIENCE: DESCRIPTIVE GEOMETRY HELPS SURVEYING INSTRUCTOR, R. P. Vreeland ..... S, 100
GRAPHIC SCIENCE—IS ENGINEERING GRAPHICS A SCIENCE?, M. McNeary ..... N, 303
GRAPHIC SCIENCE: CHAIRMAN'S MESSAGE, Wm. E. Street ..... Ja, 475
GRAPHIC SCIENCE: MIDWINTER MEETING AND SUMMER SCHOOL ....M, 569
GRAPHIC SCIENCE: COURSE FOR SCIENCE MAJORS, Eugene Paré ..... My, 798
GUIDANCE BIBLIOGRAPHY FOR MATHEMATICS ..... Je, 858

HIGH SCHOOL SCIENCE FAIRS, Watson Davis ..... O, 179
HOCKEMA, FRANK C. ..... My, 806
HUMANISTIC-SOCIAL SUMMER SCHOOL M, 591
HUMAN RELATIONS IN ENGINEERING, B. von H. Gilmer and H. W. Karn ..... M, 544

INDUSTRIAL FELLOWSHIP ANNOUNCEMENT, R. A. Morgen ..... Ja, 496
INDUSTRIAL RESEARCH AND A PROFILE OF THE RESEARCH WORKER, E. W. Engstrom ..... D, 311
INFLUENCE OF ASEE MISSION REPORT ON JAPANESE ENGINEERING EDUCATION, Kinji Shimizu ..... N, 260
IN THE NEWS ..S, 24; O, 167; N, 289; D, 326, 365; Ja, 478; A, 617; My, 795
IOWA STATE COLLEGE—HOST FOR ASEE ANNUAL MEETING ..... Ja, 417
IOWA STATE COLLEGE—A CAMPUS INTRODUCTION ..... M, 531
IOWA STATE COLLEGE, ENGINEERING RESEARCH ..... My, 755

"JETS" FOR HIGH SCHOOLS ..... M, 559

KEREKES PRESIDENT ACI ..... Ja, 426

LAMME AWARD, Vannevar Bush ....S, 94
LIBERAL SCIENTIFIC EDUCATION, James R. Killian, Jr. ..... My, 793
LOCATION OF AMES, IOWA ..... M, 530

MACELWANE, JAMES B. ..... My, 806
MIT ADVANCED STUDY SCHOOL ...My, 775
MIT's PRACTICE SCHOOL, Robert C. Reid ..... Ja, 441
MATHEMATICAL BIBLIOGRAPHY ....Je, 858
MATHEMATICS CONFERENCE ..... Ja, 452
MATHEMATICS IN ENGINEERING ....M, 585
MATHEMATICS TEACHER IN ENGINEERING, F. Virginia Rohde ..... M, 555
MCGRAW AWARD JAMES H. ..... N, 278
MECHANICAL ENGINEERS AND NUCLEAR POWER REACTOR DESIGN, Fritz, R. J. ..... Je, 827
MECHANICS TEACHERS—THEIR CROSS AND THEIR CROWN, D. H. Pletta Ja, 453
MEMBERSHIP APPLICATION ....Ja, ix; M, x; My, x
MICHIGAN PROGRAMS ..... Ja, 471
MICROWAVE ENGINEERING: HOW A NEW COURSE IS ADOPTED, Charles Süsskind ..... Je, 838
MOTION AND TIME STUDY ..... M, 568

NATIONAL ENGINEERS' WEEK ..... D, 404
NSF GRANTS ..... My, 792
NEED FOR MORE "KNOW-WHY," Jess H. Davis ..... My, 790
NEEDS OF ELECTRIC POWER INDUSTRY FOR NUCLEAR ENGINEERS, R. W. Hartwell and H. A. Wagner ...O, 152
NEW JOURNAL EDITOR ..... N, 214

NEW MEMBERS ....S, 104; O, 206; N, 306; D, 407; Ja, 481; M, 580; A, 611; My, 804; Je, 860
NEW LOWELL COURSE .....Ja, 460
NOMINATION BLANK .....Ja, x
NOTE TO AUTHORS .....My, 770
NUCLEAR ENGINEERING AND SCIENCE CONGRESS .....N, 268
NUCLEAR ENGINEERING RESEARCH, SURVEY, H. S. Isbin .....S, 76
NUCLEAR RESEARCH PROJECTS IN MECHANICAL ENGINEERING .....Je, 857

OAK RIDGE INSTITUTE .....M, 606
OFFICERS, DIVISION, COMMITTEE, AND SECTION .....O, 204
ON TEACHING DESIGN, Chesley J. Posey .....M, 547
ON TEACHING PHYSICAL MECHANICS, Seeger, R. J. .....Je, 842
OPERATION COOPERATION, W. L. Howland .....Ja, 467
OUR OUTPUT PROBLEM, E. J. Rising .D, 379

PHYSICS FOR ENGINEERS, J. A. Sauer and D. E. Hardenbergh .....D, 349
PHYSICS IS NOT ENGINEERING, R. J. Seeger .....O, 127
PLACE OF SOLID STATE PHYSICS IN ENGINEERING, H. V. Fairbanks ..N, 251
PREDICTION OF ENGINEERING POTENTIALITY IN HIGH SCHOOL STUDENTS, A. P. Johnson .....O, 135
PRESIDENT, M. M. BORING—BIOGRAPHY S, 1
PRESIDENTIAL ADDRESS, N. W. Dougherty .....S, 8
PROBLEMS IN NUCLEAR METALLURGY, Stuart McLain and Frank G. Foote .....My, 760
PROFESSIONAL DEVELOPMENT OF THE YOUNG ENGINEERING TEACHERS, D. R. Lamb .....N, 274
PROFESSIONAL ENGINEERING ETHICS IN PRACTICE, K. A. Meade .....O, 140

RECOGNITION AND INCENTIVES FOR GOOD TEACHING, Survey, H. W. Case .S, 81
RECOGNIZING POTENTIAL ENGINEERS AMONG SCIENCE STUDENTS, R. D. MacCurdy .....N, 255
REPORT OF AUDITOR .....D, 397
REPORT OF THE COMMITTEE ON ATOMIC ENERGY EDUCATION, P. N. Powers.....N, 281
REPORT OF ECRC, H. K. Work ....N, 279
REPORT, ETHICS COMMITTEE .....S, 61
REPORT, ENGINEERING SCHOOL LIBRARIES COMMITTEE, J. H. Moriarty D, 396
REPORT, EVALUATION, ENGINEERING EDUCATION .....S, 25
REPORT OF THE SECRETARY, 1954/55 O, 190
REPORTS OF THE VICE PRESIDENTS ..O, 194
REPORT, YET COMMITTEE, P. Weinberg .....N, 283
RESOLUTIONS COMMITTEE REPORT ..O, 203
REVISED ASTE DATA INDEX .....M, 572
"RISK ANALYSIS," DISCUSSION OF ..Je, 859
RISK ANALYSIS IN ENGINEERING ECONOMY STUDIES, F. A. Gitzendanner .....O, 182
ROLE OF COLLEGES IN NUCLEAR ENGINEERING EDUCATION, G. A. Hawkins .....O, 123
ROLE OF PHYSICS IN ENGINEERING EDUCATION, AIP Committee .....M, 592
ROYS, FRANCIS W., V. P. .....My, 801
RUSSIAN SECONDARY EDUCATION ...Ja, 507

SECTION MEETINGS ....S, 106; O, 210; N, 308; D, 411; Ja, xi; M, ix; A, 618; My, ix
SENTENCE LENGTH IN SCIENTIFIC WRITING, Harry F. Arader .....M, 560
SMALL COMPANY LOOKS AT ENGINEERING EDUCATION, John L. McLucas .....Ja, 458
SPECIALISTS IN DIVERSIFICATION, H. A. Foecke .....N, 270
SPONSORED RESEARCH IN ENGINEERING COLLEGES, W. L. Everitt ....My, 779

TEACHING BASIC ELECTRIC AND MAGNETIC FIELDS—A CHALLENGE, S. Seely .....O, 176
TEACHING ENGINEERING SCIENCES, Sheldon S. L. Chang .....Ja, 456
TEACHING LEADERSHIP TO ENGINEERING STUDENTS, R. K. Watkins ..D, 391
TEACHING POSITIONS AVAILABLE ..S, 103; O, 209; N, 305; D, 406; Ja, 480; M, 576; A, 615; My, 802; Je, 865
TEACHING TIPS, F. H. Pumphrey ...S, 93
TECH. INSTITUTE BULLETINS .....Ja, 483
TECHNICAL WRITING COURSE THAT WORKS, Ray Sweigert, Jr. N, 262
TESTS FOR GUIDANCE AND COUNSELING, Marvin D. Dunnette .....Ja, 434
THERMODYNAMIC METHOD OF ATTACK, A. K. Oppenheim .....D, 332
TORGENSEN HONORED .....M, 568
TRACY, JOHN CLAYTON .....M, 584
TRENDS IN ENGINEERING EDUCATION, V. L. Parsegian .....Ja, 461

UNCONSCIOUS ART, Lee Harrisberger ..... My, 796
UNESCO AND ASEE, Howard K. Justice ..... My, 776
UNIVERSITY RESPONSIBILITY IN CONTACTING HIGH SCHOOLS, J. F. Downie Smith ..... S, 64
UNIVERSITY TECHNICAL WRITERS AND EDITORS, L. A. Rose ..... O, 146
USE OF COMPUTERS IN HANDLING STATISTICAL DATA, W. W. Baker .. O, 163
USES OF THE LABORATORY IN TEACHING ELECTRIC MACHINERY COURSES, L. A. Finzi ..... D, 321

VALUE OF RESEARCH TO GRADUATE INSTRUCTION, W. G. Pollard .... N, 226
VALUE OF RESEARCH TO THE EDUCATION PROGRAM, J. C. Warner .. D, 338
VALUE OF RESEARCH TO THE INSTITUTION, G. H. Hickox ..... N, 222
VAN LEER, BLAKE R. ..... A, 614
VDI CENTENARY CELEBRATION ... My, 786
VOLUMETRIC EFFICIENCY—AMBIGUOUS TERM, R. P. Bobco and A. L. Gosman ..... M, 565

WALKER, V.-P. PENN. STATE ..... Ja, 416
WAYS TO IMPROVE STATUS OF THE GOOD TEACHER, L. H. Johnson ..... O, 132
WEBER, PAUL, PRESIDENT ..... My, 801
WHAT INDUSTRY EXPECTS OF THE YOUNG GRADUATE ENGINEER, John Gammell ..... S, 86
WHERE ARE WE GOING IN ENGINEERING EDUCATION?, R. L. Sweigert N, 247
WHY DO ENGINEERS DISLIKE TECHNICAL WRITING, H. M. Friend ..... Je, 836

YOU CAN'T DO IT ALL AT ONCE, R. T. Howe ..... Ja, 472
YET CONTEST RULES ..... Ja, 508
YOUNG ENGINEERING TEACHER, P. Weinberg ..... D, 363
YET-ITUDES ..... O, 160
YET-ITUDES, P. L. Balise ..... S, 73
YET-ITUDES, M. Baker ..... N, 301
YET-ITUDE: YOU CAN'T DO IT ALL AT ONCE, R. T. Howe ..... Ja, 472
YET-ITUDE: A BUSMAN'S HOLIDAY, Harold A. Foecke ..... M, 573
YET-ITUDE: THE UNCONSCIOUS ART, Lee Harrisberger ..... My, 796

AUTHOR INDEX

ALLEN, F. E., Corrosion Instruction in Engineering Colleges ..... N, 267
ARADER, HARRY F., Sentence Length in Scientific Writing ..... M, 560
ARIES, R. S., Economics in Chemical Engineering ..... Ja, 446
ARMSBY, H. H., Engineering Enrollments and Degrees, 1955 ..... F, 509
ARMSBY, H. H., Future Scientists of America Foundation ..... Je, 855

BAKER, M., YET-itudes ..... N, 301
BAKER, W. W., Use of Computers in Handling Statistical Data .... O, 163
BALISE, P. L.' YET-itudes ..... S, 73
BOBCO, R. P., Volumetric Efficiency-Ambiguous Term ..... M, 565
BOLTON, J. H., The Art of Writing . O, 171
BORING, M. M., Year of Decision ... S, 4
BRANDENBURG, P. F., "Case Studies" in Materials Laboratory ..... M, 563
BURINGTON, R. S., For What Types of Careers Should We Train Mathematicians? ..... O, 115

CASE, H. W., Good Teaching Survey . S, 81
CHANG, SHELDON S. L., Teaching Engineering Sciences ..... Ja, 456
Cziner, R. M., Economics in Chemical Engineering ..... Ja, 446

DAVIS, J. H., General Studies for Engineers ..... O, 109
DAVIS, J. H., Need for More "Know-Why" ..... My, 790
DAVIS, WATSON, High School Science Fairs ..... O, 179
DEAN, J. E., Candid Comments .... S, 99
DOUGHERTY, N. W., Presidential Address ..... S, 8
DUNNETTE, MARVIN D., Tests for Guidance and Counseling ..... Ja, 434

EMBLER, WELLER, Another Look at General Studies ..... M, 551
ENGSTROM, E. W., Industrial Research and a Profile of the Research Worker ..... D, 311
EVERITT, W. L., Sponsored Research in Engineering Colleges ..... My, 779

FAIRBANKS, H. V., Place of Solid State Physics in Engineering .....N, 251
FINZI, L. A., Uses of the Laboratory in Teaching Electric Machinery Courses .....D, 321
FLANAKIN, H. A. M., Birth of a Research Project .....D, 358
FOECKE, H. A., Specialists in Diversification .....N, 270
FOECKE, H. A., YET-itude: A Busman's Holiday .....M, 573
FOOTE, FRANK G., Problems in Nuclear Metallurgy .....My, 760
FRIEND, H. M., Why Do Engineers Dislike Technical Writing? ....Je, 836
FRITZ, R. J., Mechanical Engineers and Nuclear Power Reactor Design .Je, 827

GAMMELL, JOHN, What Industry Expects of the Young Graduate Engineer .....S, 86
GITZENDANNER, F. A., Risk Analysis in Engineering Economy Studies .O, 182
GILMER, B. VON H., Human Relations in Engineering .....M, 544
GOSMAN, A. L., Volumetric Efficiency-Ambiguous Term .....M, 565

HARDENBERGH, D. E., Physics for Engineers .....D, 349
HARRISBERGER, LEE, YET-itude: The Unconscious Art .....My, 796
HARTWELL, R. W., Needs of Electric Power Industry for Nuclear Engineers .....O, 152
HAWKINS, G. A., Role of Colleges in Engineering Education .....O, 123
HAWKINS, G. A., Designing the Educational Program .....N, 241
HAZEN, HAROLD L., ECPD Accreditation-Introduction .....My, 814
HICKOX, G. H., Value of Research to the Institution .....N, 222
HOLLISTER, S. C., ECPD—Toronto Address: Need for Appraisal ....Ja, 503
HOWE, R. T., YET-itude: You Can't Do It All at Once .....Ja, 472
HOWLAND, W. L., Operation Cooperation .....Ja, 467
HUNT, D. C., Cooperative Engineering Calendars .....O, 168

ISBIN, H. S., Nuclear Engineering Research, Survey .....S, 76

JARACZ, W. A., Engineering Enrollments and Degrees, 1955 .....F, 509
JOHNSON, A. P., Prediction of Engineering Potentiality in High School Students .....O, 135
JOHNSON, L. H., Ways to Improve Status of the Good Teacher .....O, 132
JUSTICE, HOWARD K., UNESCO and ASEE .....My, 776

KALSEM, P. J., Educational Requirements for Technical Editors ..Je, 832
KARN, H. W., Human Relations in Engineering .....M, 544
KEREKES, FRANK, English Program as Engineering Teachers View It .Ja, 427
KILLIAN, JAMES R., JR., Liberal Scientific Education .....My, 793
KIMBARK, E. W., Engineering Education in Brazil .....D, 353
KIRKBRIDE, C. G., Education for Research in Industry .....N, 216

LAMB, D. R., Professional Development of Young Engineering Teachers N, 274
LESSER, ARTHUR, JR., Engineering Economy Committee Functions ....Ja, 498
LEVINE, M., Candid Comments ...D, 402

MACCURDY, R. D., Recognizing Potential Engineers .....N, 255
MATTILL, J. I., 63rd Annual Meeting S, 14
MCCABE, W. L., ECPD—Resolution; Origins of Proposal .....Ja, 501
MCLAIN, STUART, Problems in Nuclear Metallurgy .....My, 760
MCLUCAS, JOHN L., Small Company Looks at Engineering Education Ja, 458
MCNEARY, M., Graphic Science ...N, 303
MEADE, K. A., Professional Engineering Ethics in Practice .....O, 140
MORGEN, R. A., Industrial Fellowship Announcement .....Ja, 496
MORIARTY, J. H., Report, Engineering School Libraries Committee ...D, 396

OPPENHEIM, A. K., Thermodynamic Method of Attack .....D, 332

PARÉ, EUGENE, Graphic Science: Course for Science Majors .....My, 798
PARSEGIAN, V. L., Trends in Engineering Education .....Ja, 461
PEARSON, D. S., Cracking the Creative Nut .....O, 121
PLETTA, D. H., Mechanics Teachers—Their Cross and Their Crown .Ja, 453
POLLARD, W. G., Value of Research to Graduate Instruction .....N, 226

POSEY, CHESLEY J., On Teaching Design .....M, 547
POULTON, J. F., Coordination of Architecture, Engineering, and Construction by the Project Method ...D, 383
POWERS, P. N., Committee on Atomic Energy Education .....N, 281
PUMPHREY, F. H., Teaching Tips ...S, 93

REID, ROBERT C., MIT's Practice School Ja, 441
RETTALIATA, J. T., Education by Research Training .....D, 327
RISING, E. J., Our Output Problem .D, 379
RISING, E. J., Corps of Engineers Student Program .....My, 771
ROHDE, F. VIRGINIA, Mathematics Teacher in Engineering .....M, 555
ROSE, L. A., University Technical Writers and Editors .....O, 146
RUBEY, H., Enrollment and Incomes in Civil Engineering Can Be Increased .....N, 236

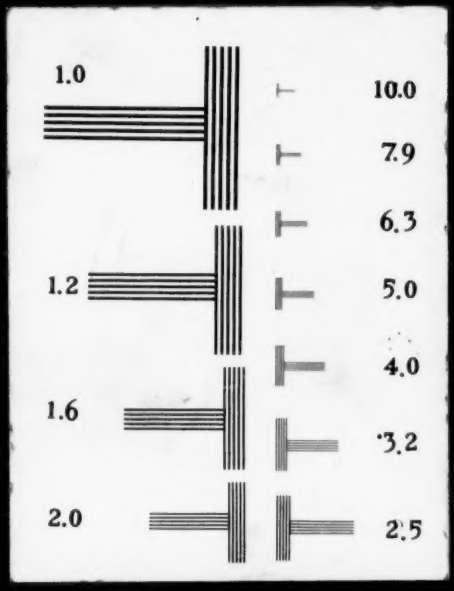
SAUER, J. A., Physics for Engineers .D, 349
SAVILLE, THORNDIKE, ECPD—Proposal for Survey of Profession .....Ja, 500
SEEGER, R. J., On Teaching Physical Mechanics .....Je, 842
SEEGER, R. J., Physics is Not Engineering .....O, 127
SEELY, S., Teaching Basic Electric and Magnetic Fields—A Challenge ..O, 176
SHIMIZU, KINJI, Influence of ASEE Mission Report on Japanese Engineering Education .....N, 260
SMITH, G. WALLACE, Survey in Engineering Mechanics .....M, 536
SMITH, J. F. DOWNIE, University Responsibility in Contacting High Schools .....S, 64
SNELL, J. R., Fight for Ethics .....N, 230
STREET, WM. E., Graphic Science: Chairman's M[illegible]e .....Ja, 475
SÜSSKIND, CHARLES, [illegible]rowave Engineering .....Je, 838
SWEIGERT, R. L., W[illegible]re We Going in Engineering Ed[illegible]tion? ....N, 247
SWEIGERT, RAY, JR., Technical Writing Course That W[illegible]rks .....N, 262

UPSON, R. H., Candid[illegible] C[illegible]nents ..D, 401

VAN VLECK, J. H., Blurre[illegible]orders of Physics and Engineer[illegible] .....D, 366
VREELAND, R. P., Descriptiv[illegible] Geometry Helps Surveying Instru[illegible]r ....S, 100
WAGNER, H. A., Needs [illegible]lectric Power Industry for Nuc[illegible] Engineers .....O, 152
WALKER, ERIC A., Can 500,[illegible] Engineers Be Professional? .....Ja, 421
WARNER, J. C., Value of Rese[illegible]ch to the Education Program .....D, 338
WATKINS, R. K., Teaching Lea[illegible]ship to Engineering Students .....D, 391
WEINBERG, P., Report, YET C[illegible]mittee .....N, 283
WEINBERG, P., Young Engin[illegible]ng Teacher .....D, 363
WHITE, ARDIS, Field Research in Civil Engineering .....My, 768
WILSON, W. E., Communication [illegible] lems in the Engineering Scie[illegible] Curriculum .....
WOLFE, J. K., Evaluation of Engineering Education .....D, 342
WORK, H. K., Report ECRC .....N, 279

ZIMMERMAN, JOSEPH F., Extra-Curricular Activities .....My 87

RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.